AD NUMBER
AD022438
CLASSIFICATION CHANGES
TO: unclassified
FROM: restricted
LIMITATION CHANGES
TO: Approved for public release, distribution unlimited
FROM: Controlling Dod Organization...Army Medical Research Lab., Fort Knox, KY.
AUTHORITY
USAMRL ltr, 26 Feb 1970; USAMRL ltr, 26 Feb 1970

CLASSIFICATION CHANGED

AD

FROM RESTRICTED TO UNCLASSIFIED

Insert Class Insert Class

22438

ON September 15, 1954 By authority of Classification cancelled in accordance with Executive Order 10501 issued 5 November 1953

Document Service Center
Armed Services Tech. Info Agen

20030625052

This action was rendered by [illegible] OSN

Name in full Date

ΓICΞ: THIS DOCUMENT CONTAINS INFORMATION AFFECTING THE

ΓIONAL DEFENSE OF THE UNITED STATES WITHIN THE MEANING

THE ESPIONAGE LAWS, TITLE 18, U.S.C., SECTIONS 793 and 794.

E TRANSMISSION OR THE REVELATION OF ITS CONTENTS IN

Y MANNER TO AN UNAUTHORIZED PERSON IS PROHIBITED BY LAW.

ARMY MEDICAL RESEARCH LABORATORY

FORT KNOX, KENTUCKY

REPORT NO. 113

COLD INJURY - KOREA 1951-52*

by

COLD INJURY RESEARCH TEAM

from

ARMY MEDICAL RESEARCH LABORATORY
FORT KNOX, KENTUCKY

1 April 1953

*Subtask under Environmental Physiology, AMRL Project No. 6-64-12-028, Subtask (8K) Cold Injury Studies

NOTICE: THIS DOCUMENT CONTAINS INFORMATION AFFECTING THE NATIONAL DEFENSE OF THE UNITED STATES WITHIN THE MEANING OF THE ESPIONAGE LAWS, TITLE 18, U.S.C., SECTIONS 793 and 794. THE TRANSMISSION OR THE REVELATION OF ITS CONTENTS IN ANY MANNER TO AN UNAUTHORIZED PERSON IS PROHIBITED BY LAW.

GENERAL TABLE OF CONTENTS

REPORT NO. 113

GENERAL TABLE OF CONTENTS (Cont.)

Submitted by:
Cold Injury Research Team
Kenneth D. Orr
Lt. Col., MC
Commanding

Approved: Ray G. Daggs
RAY G. DAGGS
Director of Research

Approved: Carl F. Tessmer
CARL F. TESSMER
Lt. Col., MC
Commanding

SUMMARY OF ACTIVITIES

COLD INJURY RESEARCH TEAM

ARMY MEDICAL RESEARCH LABORATORY

KOREA, 1951-52

by

Kenneth D. Orr
Lt. Col. MC, USA

TABLE OF CONTENTS

SUMMARY OF ACTIVITIES
COLD INJURY RESEARCH TEAM
ARMY MEDICAL RESEARCH LABORATORY
KOREA, 1951-52

I. INTRODUCTION

With the onset of cold weather in Korea during the winter of 1950-51 the Medical Services of the Armed Forces of the United Nations were not indoctrinated in the procedures for classification, treatment and management of frostbite patients. The etiological factors of frostbite formulated at this time were somewhat speculative in nature with a great deal of emphasis being placed upon the terms "self-infliction" and "command responsibility". Very little attention was paid to the influence of existing weather conditions, logistical support of the troops and especially the influence of intensity of combat upon the incidence of this type of injury.

On [illegible] November 1950 a treatment center for frostbite casualties was established in Osaka, Japan, by the Surgeon of the Japan Logistical Command, United States Army. Between 1 December 1950 and 1 April 1951, 4,216 cold injury casualties were admitted to this center for treatment and disposition. Due to existing circumstances only a limited study of the etiological, pathological, clinical and therapeutic aspects of frostbite could be made. The report* of this limited study was published on 1 November 1951.

---

*Orr, K. D. and D. C. Fainer. Cold injuries in Korea during winter of 1950-51. AMRL Special Report, 1 Nov. 1951. and Medicine 31: 177, 1952.

Because of the many provocative aspects to the problem of frostbite relative to etiology, classification, pathophysiology and management as given in this November 1951 report, a cold injury conference was held at the Army Medical Research Laboratory, Fort Knox, Kentucky, on 19-21 July 1951. The members of this conference were from the Medical Services of the Army, Navy, Air Force, National Research Council, Veterans Administration and civilian research groups. The discussion and findings of the conference group resulted in a recommendation to the Surgeon General, United States Army, that a Cold Injury Research Team be organized and sent to the Far East Command, United States Army, for the winter 1951-52 to assist in the recognition, treatment, study and disposition of frostbite casualties. In order to facilitate the achievement of these objectives it was suggested that all cold injuries be hospitalized at one center in Korea with further evacuation to a similar special treatment center in Japan. It was further recommended that the activities of the proposed Cold Injury Research Team be directed to the following:

1) Information

The team should provide to the Medical Services of the Far East Command the latest information regarding diagnosis, evacuation, treatment, disposition and utilization of cold injured personnel derived from current studies of frostbite. The research group should serve also as consultants to the Theater and Army Surgeons on matters pertaining to cold injuries.

2) Climatology

Weather stations should be established in every

United States regiment and battalion so that a complete set of meteorological data could be obtained as close to the scene of cold injured casualties as possible. This data could be used for evaluating the incidence of frostbite in relation to the performance of the unit, the individual soldier and his protective clothing. The data could also be useful in evaluating the performance of all combat equipment and in the planning of combat missions with respect to duration of the mission and type of protective clothing needed (See Cold Injury Code Sheet, Appendix I).

3) Cold Weather Clothing, Equipment and Training

A representative of the Quartermaster Corps should make detailed studies regarding:

a) Status of the individual cold weather clothing and cold weather equipment of the United States infantry divisions as of 20 November 1951.

b) Status of the cold weather training in the Eighth Army as of 1 December 1951.

c) Status of cold weather clothing and equipment, its usage and deficiencies, for each frostbite casualty.

d) General deficiencies of the cold weather clothing and equipment used by personnel of the Eighth Army during the winter months of 1951-52 (See Basic Quartermaster Questionnaire for Cold

Injury Casualties and Clothing List for Cold Injury Casualties, Appendix I).

4) <u>Constitutional Susceptibility to Cold Injury and Cold Stress</u>

An attempt should be made to devise a suitable screening program for the selection or elimination of highly susceptible, average susceptible and resistant individuals for combat duty in cold climates. Therefore, a study (Pre-Exposure) should be made of soldiers from combat divisions and individuals passing through the forward Replacement Depots regarding place of birth, duration of previous exposure to various climates, race, intelligence scores, constitutional factors such as body build, emotional reactions, psychological and physiological reactions (See Pre-Exposure Questionnaire, Appendix I). These studies should be made prior to the soldier's entry into combat and with subsequent examinations during and after the cold season.

5) <u>Epidemiology</u>

This phase of investigation should make an assessment of the relative significance of the multiple factors contributing to cold injury. This assessment should of necessity include a study of the environmental conditions and degree of combat activity which existed at time of occurrence of frostbite within the smaller combat units, i.e. platoons or companies. For a control group of "normal" combat soldiers the subjects should be limited to those men who were exposed to the same environmental

stress in time, geographical location and activity as the frostbite patients. Additional data should be collected regarding troop strength by units, composition by rank, race and incidence of battle casualties, non-battle casualties (accidents) and total diseases.

6) Clinical Evaluation

Accurate comprehensive records should be maintained on all cold injury cases. These reports should include data concerning the etiological factors and clinical features of each individual frostbite patient (See Cold Injury Code Sheet, Appendix I). From these records an evaluation should be made of such factors as duration of exposure, type of bootgear worn, race and method of rewarming with respect to the rate of healing of frostbite wounds. A therapeutic evaluation also should be made of the efficacy of heparin, heparin-alcohol-procaine, rutin, priscoline, hexamethonium and sympathetic ganglion blocks in the treatment of frostbite.

7) Psychiatric Evaluation

The study should be a composite one by the psychiatrist, clinical psychologist and psychiatric social worker. The study should, in general, include personality patterns of personnel subject to cold injury during combat, evidence of self-inflicted cold injuries when suspected and the nature and extent of intellectual factors in the etiology of

cold injury. The study also should include the evaluation of nonfrostbitten personnel for the purpose of "control" matching, using the same procedures as those used in the epidemiological study of cold injuries (See Psychiatric Code Sheet, Appendix I).

8) Pathology

A study and evaluation of selected biopsy and amputation material with particular emphasis on changes that might be present in blood vessels, nerves, bones, muscles and skin due to injury by cold should be made. A comprehensive bacteriological survey should be made of frostbite lesions.

9) Physiology

Studies should be made through the various stages of the clinical course of frostbite including the post-frostbite syndrome regarding the vascular response, skin temperature response and sweat rates. This study also should include detailed observations on selected patients with healed frostbite lesions when subjected to cold stress at periodic intervals. Observations should be made on the alterations of responses of these patients to cold stress when sympathetic blocks, priscoline and hexamethonium are used.

10) Nutrition

Observations should be made on cold injury cases

relative to their nutritional status, caloric intake, and ascorbic acid levels at time of cold injury and at periodic intervals thereafter. Ascorbic acid levels also should be determined on combat infantrymen who had not incurred a cold injury.

11) Hematology

Cold hemagglutinin determinations should be performed on the following groups of soldiers: frostbite patients, nonfrostbitten infantrymen who had been in combat during the winter months, infantrymen in the forward Korean Replacement Centers and soldiers arriving in the Far East from the Zone of Interior. The incidence of sickling trait should be determined among the Negro frostbite casualties.

12) Biochemical

In addition to the performance of routine laboratory procedures on the cold injury patients there also should be a study of serum proteins, fibrinogen levels, protein content of vesicular fluid and the sodium and potassium levels of blood and vesicular fluids.

II. COMPOSITION AND GENERAL ACTIVITIES OF THE COLD INJURY RESEARCH TEAM

A. Composition

Commanding Officer - Kenneth D. Orr, Lt. Col., MC, USA

Section stationed in Korea

Epidemiologist - Leonard M. Schuman, Cmdr., MC, USPHS
Meteorologist - Norman Sissenwine, Capt., USAF, AUS
Quartermaster Corps Observer - Donald G. Rice, Capt., QMC, AUS
Medical Observer - Clifford W. Ulrich, Capt., MC, AUS
Medical Observer - Sylvan L. Weinberg, Capt., MC, AUS
Internist - Harold A. Lyons, Cmdr., MC, USN
Internist - Frank A. Massari, 1st Lt., MC, USAF
Anesthiologist - James H. Matthews, 1st Lt., MC, AUS
Physiologist - Ellsworth B. Cook, Lt. Cmdr., MSC, USN
Physiologist - Harold T. Meryman, Lt., MC, USN
Photographer - Merle H. Rhodes, CPO, USN
Laboratory Technician - David H. Bremman, Cpl., USA

Section stationed in Japan

Executive Officer - Jesse W. West, Major, MSC, AUS
Internist - Bruce M. Wimer, Capt., MC, AUS
Internist - Coleman D. Caplovitz, 1st Lt., MC, USAF
Surgeon - Robert E. Lempke, 1st Lt., MC, AUS
Pathologist - Donald B. Frazier, Capt., MC, AUS
Nutritionist - Louis J. Polskin, Capt., MC, AUS
Biochemist - Leonard J. Bodenlos, Lt., MSC, USN
Physiologist - Domenic A. Vavala, 2nd Lt., MSC, USAF
X-Ray Technician - Donald A. Loftus, CPO, USN
Photographer - Raymond H. Zink, Sgt., USA
Laboratory Technician - Glenn E. Case, Sgt., USAF
Laboratory Technician - Robert L. Rease, Sgt., USA
Laboratory Technician - Walter R. Koehler, Cpl., USA
Electronic Technician - Robert A. Crawford, Cpl., USA

B. General Activities

The research group departed from Fort Knox, Kentucky on 8 October 1951 and arrived in Tokyo, Japan on 13 October 1951. On 14-15 October conferences were held with the Deputy Surgeon of the Far East Command, the Surgeon of the Japan Logistical Command and the Far East Command consultants in Medicine and Psychiatry regarding the proposed studies of frostbite during the winter months of 1951-52.

The team and its equipment were moved by rail to Osaka Army Hospital on 16 October 1951. Three hundred beds in this

hospital had been set aside for the treatment of cold injuries. From 18 October to 26 October the members of the team were engaged in making final preparations for the study of cold injuries.

The Korean Section of the team arrived at the 25th Evacuation Hospital, Taegu, Korea on 27 October 1951. This hospital (300 beds) had been designated as the Cold Injury Center for Korea by the Surgeon, Eighth Army. A conference was held with the Surgeon, Eighth Army, on 28 October 1951 at which time he recommended that, due to anticipated rapid evacuation from division medical installations and the close proximity of mobile army surgical hospitals (MASH), all specific therapy be started at the MASH level with the base of operation for the two forward medical observers at this level. Following this conference (29 Oct. 1951) a letter was prepared requesting permission from the Eighth Army General Staff to establish, equip and maintain weather stations in all United States battalion and regimental command posts. Permission to establish weather stations finally was granted by Eighth Army Headquarters on 14 November 1951. From 5 November to 22 November certain personnel of the Korean Section assisted in a pre-exposure survey among the infantrymen of the 3rd and 25th Infantry Divisions.

The Cold Injury Center in Korea was closed on 23 March 1952 and the personnel of this Center returned to Osaka, Japan on 25 March 1952. Operation of the Cold Injury Center, Osaka Army Hospital ceased on 20 April 1952. Movement of the Cold

Injury Research Team to the Army Medical Research Laboratory, Fort Knox, Kentucky began on 14 April 1952 and was completed on 9 May 1952.

III. MATERIAL FOR STUDY

The clinical information derived from this study of frostbite was, of necessity, confined to the relatively late stages of the injury. The original plan of study had emphasized the initiation of treatment and the obtaining of clinical and physiological observations immediately after injury. Actually, delays in evacuation prevented observations or treatment from being initiated on the entire group of frostbite casualties until an average of 102 hours after injury. In a select group of 108 patients, where a deliberate attempt was made to exclude those cases with older injuries, there still was a lapse of an average of 43 hours between cessation of the cold exposure and arrival of the casualty at the forward mobile surgical hospital where treatment and clinical observations could be started. In this special group physiological measurements were further delayed from 24 to 48 hours as a result of transferring the patient from the forward hospital to the Cold Injury Center at Taegu, Korea. These delays in initiating treatment and studies during the early phase of the injury were due to the following factors:

1) The casualty often failed to report to a medical installation immediately after injury. Many times frostbite lesions were not discovered until the time of a foot inspection by the squad leader, platoon commander, company aidman or battalion surgeon. In a few units the commanding officer attempting to strengthen his cold

injury prevention program made such injuries a subject of disciplinary action. This approach caused these injuries to go "underground", i.e. to be concealed or suppressed either by the patient himself, his platoon leader or his unit surgeon.

2) The low incidence of frostbite during the winter of 1951-52 coupled with a low over-all casualty rate resulted in less prompt transportation along the entire chain of evacuation (battalion aid station to the Cold Injury Center) despite orders to evacuate cold injury patients promptly. In only one instance, at a time when casualties were numerous and full loads (planes, trains, ambulances) resulted, was evacuation prompt. Frostbite patients reporting to their battalion aid stations 2 to 4 hours after injury arrived in the Korean Cold Injury Center 6 to [illegible] hours later.

3) Inclement weather at times prevented air evacuation of the cold injury cases from the forward hospitals to the special treatment center.

4) Guerrilla activity by the enemy between the forward area and the treatment center prevented the operation of ambulances and hospital trains during the hours of darkness. This often caused a delay of 12 to 24 hours in evacuation.

The above factors could have been modified by locating the special treatment center closer to the mobile surgical hospitals. Location of the center during the winter of 1951-52, as selected by the Eighth Army Surgeon, was predicated upon the following factors:

1) Security from enemy action in the event of retrograde movement.

2) Equal accessibility from all forward medical installations from the standpoint of terrain.

3) Minimal distance of evacuation.

4) Availability of adequate hospital facilities in relation to priority of type of casualty.

5) A nearby airstrip capable of receiving and dispatching to Japan the larger type evacuation aircraft (C-54).

The first cases of frostbite occurred on 22 November 1951 in the 17th Infantry Regiment, 7th Infantry Division. The last case of frostbite occurred on 19 March 1952.

The number of cases admitted to the Cold Injury Center in Korea from 23 November 1951 to 23 March 1952 were:

Frostbite, confirmed cases, United States troops	716
*Frostbite, confirmed cases, United Nation troops	83
**I.C.C.	101
***Less than first degree frostbite or previously cold injured	55
Total	955

*United Nation cases refers to frostbite among Ethiopian, Colombian, Thailand and Philippine troops.

**I.C.C. denotes "Ill Classified Condition of the Feet" manifested by hyperhidrosis, maceration, partial denudation of the sole of the foot, erythema and pain.

***Patients who had a cold exposure but not of sufficient degree to bring about tissue changes indicative of first degree injury. Previously cold injured refers to those patients who had had a frostbite prior to the winter of 1951-52 and now complained of cold hyperhidrotic feet.

The number of frostbite cases admitted to the Cold Injury Center in Osaka Army Hospital from 25 November 1951 to 26 March 1952 were:

First degree	109
Second degree	274
Third degree	124
*Fourth degree	32
I.C.C.	11
Total	550

The distribution of the 716 confirmed cases of frostbite among United States troops by degree of severity was:

First degree	279	(39.0%)
Second degree	261	(36.4%)
Third degree	143	(20.0%)
Fourth degree	33	(4.6%)

Throughout the course of study of frostbite during the winter of 1951-52 United States soldiers were used as controls in different phases of the investigation. The distribution of the control subjects who were examined by members of the Cold Injury Research Team was as follows:

Pre-Exposure Survey (Korea)	1,628
Epidemiological Survey (Korea)	523
Bootgear and Physical Examination Survey (Korea)	350
Psychiatric Survey (Japan and Korea)	90

*Twenty-nine of the 32 cases of fourth degree frostbite were transferred to the Zone of Interior for definitive surgery and disposition.

Cold Hemagglutinin Survey		8,921
Korea	3,387	
Rest and Recreation Center (Japan)	4,257	
Camp Drake (Japan)	1,277	
Ascorbic Acid Survey		1,698
Rest and Recreation Center (Japan)	1,170	
Camp Drake (Japan)	528	
Foot Sweat Determination (Japan)		25
Foot Sweat Determination (Fort Knox)		24
Cold Stress Survey (Japan)		5
Total Number of Subjects		13,264

Total number of soldiers including cold injury casualties and control subjects used in this study was 14,219.

IV. RESULTS

Specific details regarding materials, subjects, methods and analytical results of each study may be found in the appended sections (I through XV). The pertinent findings derived from each study is given below.

A. Dissemination of Information

This aspect of the program was active throughout the winter months of 1951-52. Lectures and conferences were held in Korea at regional medical meetings and at various medical installations such as medical companies, clearing platoons, mobile surgical hospitals and evacuation hospitals. The majority of medical officers stationed in Korea were visited periodically either by the Epidemiologist, the Forward

Medical Observers, the Meteorologist, the Quartermaster Corps Observer or the Commanding Officer of the Team. Lectures concerning prevention and management of cold injuries were given at three regional medical meetings in Japan which were attended by a majority of the medical officers assigned to the Japan Logistical Command. Timely information regarding cold injuries, its management and prevention was distributed to all medical officers concerned by the following publications:

1) The Surgeons Circular Letter, F.E.C., October 1951.
2) Information Bulletins No. 36, 39, 42, Office of the Surgeon, Headquarters, EUSAK.
3) Directives from Surgeon, EUSAK, 18 January 1952 on "Early Management of Cold Injuries".

B. A Meteorological Evaluation, Korea, 1951-52 (See Section I)

On 14 November 1951 Eighth Army Headquarters directed the United States regiments and battalions to provide the manpower required for the meteorological program. This program required observations of temperature, humidity, wind speed, weather and ground surface conditions every 3 hours at regimental level (about 40 man-minutes per 24 hours) and observations of temperature and ground conditions at battalion level every 6 hours (8 man-minutes per 24 hours).

The Team Meteorologist trained the appointed personnel in the technique of obtaining and recording the meteorological data and the local application of these data. A weather kit containing instruments, instructions and data forms was issued to each United States battalion and regiment in Korea.

Weather variations between the United States regiments during the 1951-52 winter were not great. Factors contributing to the equalization of temperatures between regiments included cloudy weather, wind and frequent interchange of identical location between regiments. The coldest weather was encountered in the eastern sector of Korea. Troops in the western sector, where the front extended southward, experienced warmer weather. The 1951-52 winter was 10 to 15 degrees (F.) warmer than the 1950-51 winter.

The Eighth Army General Staff, recognizing the importance of continued application of meteorological data to the smaller combat unit activities, decided to adopt the weather program on a permanent basis. A command letter was issued on 24 February 1952 by Eighth Army Headquarters, subject "Change of Responsibility for Supervision of Local Weather Station Program". This letter directed the Assistant Chief of Staff, G-2, to assume general staff supervision of the weather program and that the Signal Officer, Eighth Army, be responsible for the operational control of the program. The fuller applications and permanent adoption of the meteorological program at regimental level are currently being studied.

Analyses dealing with the meteorological data and their relationship to frostbite and other causative factors are presented in the epidemiological section of this report.

C. An Evaluation of the Supply, Utilization and Adequacies of Winter Clothing for the United States Army in Korea, 1951-52 (See Section II)

During the months of November and December 1951 the Quarter-

master Corps Observer visited all United States corps, divisions and regiments of the Eighth Army and interviewed their quartermaster and supply personnel regarding the status of cold weather clothing and equipment within the unit. The Observer also interviewed 350 frostbite patients and obtained from each case a complete list of clothing worn at time of injury. Particular attention was paid to deficiencies in availability, use and construction of each item.

From the surveys and interviews certain conclusions were reached. The supply of winter clothing was adequate and very effectively handled at all echelons of supply. With few exceptions the necessary cold weather clothing was available in sufficient time to provide the troops protection against the Korean environment. The wet-cold uniform issued to United States troops in Korea for the winter of 1951-52, in most cases, provided adequate insulation and protection against the most severe environmental conditions experienced. The shoepac provided greater protection to troops in the rear or noncombat areas than did the leather combat boot. The insulated rubber combat boot was found to be the most suitable bootgear for wet-cold conditions. The insulated boot was probably directly responsible for a reduction in the incidence of frostbite of the feet sustained by United States soldiers in Korea during the winter of 1951-52. The trigger finger mittens provided the most protection against cold injury but did not provide a satisfactory degree of dexterity, therefore, were often removed. The wet-cold training program, winter

1951-52, was superior to that of 1950-51.

D. Pre-Exposure Survey of Combat Troops, Korea, 1951-52 (See Section III).

A total of 1,628 front-line infantrymen were studied during the period 8 November 1951 to 1 February 1952. An additional 120 hospitalized frostbite patients were interviewed.

The population represented by the pre-exposure questionnaire reflected a random sampling of the Eighth Army in so far as the distribution between Whites and Negroes was concerned. The distribution of this group by climatological region of origin did not differ from that of the epidemiological control group. This permitted combination of these two groups for statistical evaluation of climatological origin.

Only two of the 1,628 infantrymen eventually became frostbite casualties. Consequently, no analysis of the pre-exposure data was attempted in order to delineate possible factors of constitutional susceptibility to cold injury.

E. Epidemiology of Frostbite, Korea, 1951-52 (See Section IV)

An epidemiological study of the relationship of cold trauma to the combat soldier in Korea during 1951-52 dealt with 1,044 cases of cold injury. Data on 716 cases of frostbite and 455 "bunker-mate" controls were analyzed. In addition, selected data on 1,623 pre-exposure controls were utilized.

Relatively high linear correlations of frostbite incidence with daily average temperature, daily minimum temperature and daily average windchill were obtained. Separation of data according to intensity of combat permitted fairly reliable prediction formulae to be calculate[illegible] Though applicable only

to comparable situations, the method appears to hold promise for future prediction calculations in other types of situations. The mean daily minimum temperature to which the cases were exposed was 11° F. and the absolute lowest temperature was -11° F. The mean windchill during exposure was 800 Kg. cal/M²/hr.

The mean duration of exposure of frostbitten cases was 10 hours, but varied with the specific type of activity.

Although both cases and "bunker-mate" controls were exposed to similar environmental factors including specific "micro-activity" such as immobilizing enemy action, the cases showed markedly less muscular movement than did the controls.

The absolute number of frostbite cases of the feet occurring in shoepacs was greater, but calculations equalizing exposure revealed that the leather combat boot was more conducive to frostbite and more frequently caused greater severity of injury.

The following bootgear-sockgear combinations were inadequate in insulating power for the Korean climatic conditions and led to a significantly greater number of frostbite cases:

a) A single pair of cushion sole socks in leather boots.

b) A single pair of cushion sole socks in shoepacs.

Bootgear-sockgear combinations found to be constrictive and conducive to frostbite were:

a) Two pair cushion sole socks in leather combat boots.

b) One pair ski socks in leather combat boots.

Combat troops frequently failed to carry extra footwear (socks and insoles) for changing whenever the situation permitted. Of 252 cases in situations permitting sock and insole

change only 77% carried this extra footwear, whereas of 214 controls in similar situations 92% carried extra footwear. Inadequate insole change contributed significantly to frostbite incidence in troops wearing shoepacs.

A significant excess of cases with frostbitten hands wore either no handgear or incomplete glove ensembles at time of injury.

Previous cold injury indicated a predisposition to frostbite. The attack rate for soldiers not previously cold injured was 2.6 per 1,000 compared to 5.0 per 1,000 for soldiers previously cold injured.

Collateral significant evidence was demonstrated which strengthened the impressions from the neuropsychiatric study that the frostbite case tended to be a passive, negativistic, hypochondriacal individual. This evidence included the factors of less muscular activity in situations permitting greater activity, relative inattention to carrying extra footwear and less smoking.

The Negro was proven to be at greater risk of attack by frostbite (six times) when all environmental conditions were equalized. At the regimental level his rate was 35.9 per 1,000 as compared to 5.8 per 1,000 for the White soldier. Negroes had more severe degrees of frostbite than did the Whites.

The climatic region of origin of the soldier was shown to be a highly significant factor among White troops in the incidence of frostbite. Origin from warmer climates of the

United States (or Hawaii and Puerto Rico) indicated a predisposition to frostbite. There was more evidence for accustomization rather than acclimatization as an explanation for this difference.

F. Clinical Evaluation (See Section V)

A total of 716 confirmed cases of frostbite were evaluated with respect to possible contributing factors, anatomical site, severity of injury and therapy. A comparison of the incidence figures for 1950-51 with those for 1951-52 revealed the fact that there was a marked reduction in the severity of cold injuries for the latter period. Possible factors contributing to the decreased incidence are discussed in subsequent sections.

The efficacy of the therapeutic regimen was inversely related to the amount of time elapsing between the occurrence of the injury and the initiation of treatment ("pre-evacuation period"). When the pre-evacuation period exceeded 40 hours no differences in healing rates existed between the specific and supportive therapy groups. The mean length of the pre-evacuation period of 716 cases was 102 hours while the corresponding mean value for 108 cases selected for therapeutic evaluation was 43 hours. These delays were usually due to failure of the casualty to report promptly to his unit surgeon.

The most objective criteria employed to assess the relative importance of the factors contributing to frostbite were the time required for drying of the vesicles and the time for

healing of the lesions.

The drying time of vesicles and the healing of frostbite lesions were dependent upon the degree of injury, in that first and second degree lesions which were of approximately the same order required less time than did third degree injuries. The clinical course of the injuries was not influenced by the anatomical site of the lesions except in second degree where the healing time for hand cases was shorter than for feet.

The drying time of vesicles and the healing of the frostbite lesions were not dependent upon the race of the patient.

Cold exposure periods over 8 hours increased the vesicular drying time of second degree lesions and prolonged the healing of second degree frostbite of the feet. The healing of first and third degree frostbite of the feet and all lesions of the hands, however, was not prolonged by longer periods of exposure.

The vesicular drying time was shorter in cases of third degree frostbite rewarmed at room temperature as compared to similar lesions rewarmed by walking, exposure to an open fire or by massage. Third degree lesions of the feet rewarmed at room temperature took less time to heal than did equivalent injuries where rewarming was accomplished by walking, massage or exposure to an open fire. The healing of first and second degree frostbite of the feet and all lesions of the hands was not adversely affected by any one single method of rewarming.

When the delay in evacuation after injury exceeded 24 hours the drying time of vesicles was prolonged in cases of second degree frostbite. The factor of delay in evacuation also prolonged the healing of first degree frostbite of the feet. Healing of second and third degree frostbite of the feet and all lesions of the hands was not affected by this factor.

The drying time of vesicles in second and third degree frostbite of the feet was increased when the injury was incurred in leather boots as compared to similar cases wearing shoepacs or insulated rubber boots. The healing time for first, second and third degree frostbite was greater in those cases wearing leather boots as compared with patients having similar degrees of injury but equipped with shoepacs or insulated boots.

The type of handgear (or absence thereof) worn at time of injury did not alter the drying time of vesicles or the healing rate of frostbite lesions of the hands.

A longer vesicular drying time for second degree frostbite occurred when the preinjured extremity was wet. The healing of frostbite of the hands or feet was not influenced by the factor of wetness or dryness at time of injury.

In these evaluations the differences in healing times, as small as they may appear, could assume very significant proportions in terms of manpower loss and hospital cost when multiplied by hundreds of cases.

G. Treatment of Third Degree Frostbite Ulcerations by Skin Grafting (See Section VI)

The slow rate of healing of third degree frostbite ulcers of the toes is responsible for a large portion of the time

patients with this lesion are hospitalized. The resultant loss of manpower and the effect of the prolonged state of invalidism upon the morale of the individual are significant. Therefore an investigation of the possibility of hastening the restoration of epithelial continuity in these cases by the application of skin grafts was undertaken.

The effective circulation in toes with third degree frostbite was inadequate to produce survival of pinch grafts. Presumably this deficiency in the circulation is responsible for the slow rate of healing of these lesions. Treatment of the patient with a potent vasodilator drug, Mistrium, facilitated the survival of pinch grafts especially when the ulcer bed was prepared by administration of the drug for one or two days before the operation. Although it could not be proven statistically, treatment of third degree frostbite ulcers with Mistrium and pinch grafts definitely appeared to decrease the time required for complete re-epithelialization of these lesions.

H. Foot Conditions in the Several Types of Bootgear Under Combat Conditions, Korea, 1951-52 (See Section VII)

Front-line soldiers from three regiments of a United States infantry division were examined in Korea during March 1952 for sequelae following the wearing of the new insulated rubber combat boot.

The majority of the men who had worn the new boot felt that it increased sweating of the feet. The general subjective reaction to the boot was highly favorable.

The incidence of epidermophytosis, hyperhidrosis, macera-

tion and erythema was significantly higher among men wearing the insulated boot than in those wearing the shoepac or the leather combat boot. Significantly higher incidence of epidermophytosis and erythema persisted even when the insulated boot had been replaced by the leather combat boot a few days prior to examination.

The findings of the study suggested that careful attention to foot hygiene, daily sock change, avoidance of prolonged uninterrupted wearing of the boot and use of the boot under warm weather conditions are essential principles in the optimal performance of the insulated rubber combat boot. Disregard of these principles may lead to a temporarily incapacitating foot syndrome consisting of varying degrees of tenderness and pain, erythema, hyperhydrosis and maceration. Fungus infection may be superimposed or may occur in increased incidence as an additional finding.

I. A Study of the Personality Traits of Frostbite Casualties (See Section VIII)

A psychiatric-psychological study of frostbite was performed utilizing 51 patients who had incurred frostbite. Two control groups were concurrently studied, using similar procedures. One control group consisted of 20 soldiers hospitalized with combat incurred wounds, the other consisted of 51 healthy soldiers without any injuries but actively engaged in combat. All the subjects were White soldiers except for 25 Negro soldiers in the frostbite group. The frostbite group and the combat wounded group were studied by means of a social history

interview, a psychiatric interview and a battery of psychological tests including the Wechsler-Bellevue Intelligence Scale, part of the Thematic Apperception Test, the Minnesota Multiphasic Personality Inventory, a Sentence Completion Test and the Rorschach Test. The healthy combat soldiers were given the psychological tests, but were not seen for the social history or psychiatric interview.

Comparison made among the three groups of subjects indicated that frostbite patients tended to have constellations of personality traits approximating those usually psychiatrically diagnosed and classified as Immaturity Reaction and Schizoid Personalities.

The White frostbite patients utilized fewer precautions against frostbite than did the hospital controls. The hospital controls as a group gave evidence of a strong drive for such attributes as prestige, achievement and dominance which lead to respect or admiration from others. By contrast the frostbite group showed no one single dominating drive, indicating either their greater heterogeneity in this respect or a general asthenia in the drive mechanism.

When compared with combat controls the frostbite group showed a higher average score on the Rorschach factor labeled negativism. Also, the frostbite group scored higher than did the combat controls on the hypochondriasis scale of the Minnesota Multiphasic Personality Inventory.

From the statistically significant results obtained in this study o s can draw a tentative picture of a "cold-injury per-

sonality".

J. A Bacteriological, Mycological and Pathological Evaluation of Frostbite (See Section IX)

The study of frostbite from a bacteriological, mycological and pathological standpoint was confined to 108 cases who had been selected for a therapeutic evaluation.

Forty-nine percent of the cultures obtained from frostbite lesions were positive. Twelve types of bacteria, commonly found in the gastrointestinal tract, on skin and in the soil, were identified. No given bacterium was characteristic of frostbite lesions nor could any be related to severity of the injury. The bacteria were considered essentially nonpathogenic and to a large extent secondary invaders in open lesions.

Of 105 cultures for fungi only nine were positive, yielding growths of the pathogenic Trichophyton fungi. These species of Trichophyton were identified as T. mentagrophyte, T. rubrum and T. sulfureum all of which are commonly found in cases of epidermophytosis of the feet.

The pathology of severe frostbite lesions was essentially that of chronically inflamed, ulcerated and gangrenous tissue.

The bacteriological and pathological changes which might otherwise be characteristic for frostbite were obscured because the patients had received extensive antibiotic therapy and studies of their wounds were not made until 15 to 134 days after injury.

K. Foot-Sweat Studies on Frostbite Casualties, Korea, 1951-52 (See Section X)

A total of 78 frostbite patients were studied at periodic

intervals after injury with respect to alterations in sweating of the feet. There were no significant alterations in the amount of foot sweat colected with respect to the degree of injury. Patients with unilateral or bilateral frostbite of the feet showed no significant variation in the amount of sweat collected for the right and left foot. There were no racial differences in the foot-sweat measurements. The amount of sweat collected was directly related to the time interval post-injury. During the first 30 days after injury the frostbitten feet were hypohidrotic. Between 30 and 60 days after injury the feet became hyperhidrotic and remained so for at least 120 days.

L. Cold Stress Studies on Post-Frostbite Patients (See Section XI)

Part I. Skin Color Changes

The results of the cold stress study were evaluated with regard to the color changes of injured digits, severity of injury and number of weeks post-frostbite. The study also included observations on the patients while either under the influence of priscoline, hexamethonium or sympathetic blocks. There was a relationship between the degree of abnormal vasomotor lability of the frostbitten extremity and the severity of the injury. The digits which sustained a more marked degree of injury when subjected to cold stress, developed a more marked degree of cyanosis or rubor, indicative of severe vasoconstriction.

During the application of cold stress the abnormal skin color changes were altered by using either priscoline,

hexamethonium or sympathetic blocks.

The injured parts which developed abnormal skin color changes during the period of cold stress also experienced pain varying in intensity with deepening of cyanosis or rubor.

Patients during cold stress while under the influence of a vasodilator had a significant lowering of oral temperatures.

It was concluded that an injury due to cold (frostbite) altered the vasomotor response of the extremity to subsequent cold exposures in that the injured part readily developed pain and abnormal color changes indicative of marked vasoconstriction.

Part II. Skin Temperature Studies

Skin temperature studies were performed before, during and after exposure to cold of previously frostbitten and control subjects. The results, in general, substantiated clinical observations of the changes in the circulation of the involved toes which had been observed after frostbite. Shortly after injury these digits showed excessive vasoconstrictor tone which was modified in the case of the severest injuries by what appeared to be cutaneous denervation of the involved part.

Skin temperature measurements alone were not capable of defining the post-frostbite syndrome but when employed along with other clinical observations assist in the elucidation of the pathophysiology of this condition.

M. The Ascorbic Acid Status of Normal Soldiers and Frostbite Casualties, Korea, 1951-52 (See Section XII)

Serum ascorbic acid determinations were made on 228 frostbite casualties and 1,698 normal combat soldiers.

Frostbite casualties who subsisted solely on combat rations ingested approximately one-half to one-third of the calories normally required for satisfactory nutrition and performance in the cold. The discarding of the coffee and cocoa powders in the packaged combat ration which contain most of the daily supply of ascorbic acid necessarily reduced the vitamin C intake to a low level.

The hospital diet (Osaka Army Hospital) maintained or improved slightly the initial vitamin C concentration of the blood (but not of the urine) of frostbite casualties. There was a linear relationship in frostbite cases between the initial concentration of serum ascorbic acid and the number of days of daily supplementation of 250 mgm. of vitamin C to saturate the serum with ascorbic acid. Among 95 frostbite patients, 76 required from 450 to 4,000 mgm. of ascorbic acid, over a period of 1.8 to 16 days, to achieve serum saturation. The utilization of ascorbic acid by the frostbite casualty was high.

The vitamin C concentration of sterile vesicular fluid was directly related to the amounts of vitamin C found in the blood sera.

Low blood serum ascorbic acid concentrations were more frequently found among patients with severe frostbite (third and

fourth degree). Fifty percent of the 1,698 healthy United States soldiers stationed in the Far East exhibited serum ascorbic acid levels which averaged 0.5 mgm. per 100 cc. This value was considered to be low.

N. Cold Hemagglutination Study, Korea, 1951-52 (See Section XIII)

Standardization of the cold hemagglutinin test was essential in the investigation dealing with frostbite since conclusions were based on a statistical comparison of the titers of several populations of soldiers.

A study to determine the cause or effect relationship of cold hemagglutination to frostbite was made by comparing several different populations of frostbite patients and control subjects.

This study indicated that there was a high incidence of cold hemagglutinins in normal soldiers. The factor of greatest importance for eliciting this high incidence was believed to be due to the careful control of the reading temperature.

A racial difference in cold hemagglutinating tendencies was found. The United States Negroes had significantly higher titers than Whites. The Mongolian race had much higher titers than either White or Negro.

Brief repeated cold exposures of post-frostbite patients had no appreciable effect on their existing cold hemagglutinin titers.

No relationship was demonstrated between the cold hemagglutinin titers and the anatomical site of frostbite injury.

No significant correlation was found between titers and

maximum degree of frostbite among White patients. The titers for Negroes with third and fourth degree frostbite were significantly higher than cases with second degree.

There was no evidence of an alteration of titer distinctly attributable to frostbite itself. This evidence was derived from statistics which showed no significant alteration in serial titers over a period of 6 weeks post-frostbite.

There was no detectable correlation between cold hemagglutinin titer and minimum temperature during exposure, average windchill during exposure or duration of exposure. Likewise correlations between titers of patients with third degree frostbite and minimum temperature during exposure or duration of exposure were not significant. This lack of significant positive correlations for the above factors indicated that cold hemagglutination was not of significant importance in the pathogenesis of frostbite.

Certain portions of the control group were not homogeneous thereby limiting the validity of some comparisons made with the frostbite patients. Analyses indicated that climatic environment might have a significant modifying affect on cold hemagglutinin titers. A theory was proposed that when an individual is exposed to cold weather for weeks or months a reduction in titer occurs as a result of an increased rate of destruction of cold agglutinin. The comparisons between titers of control subjects from Korea, United States and Hawaii were compatible with such a theory in that those coming from warmer climates had higher titers. Comparisons

between cold hemagglutinin titers and native climatic regions failed to show significant differences, indicating that if such differences had existed there was no permanent alteration by past environment. The cold hemagglutinin titers among those groups which were most homogeneous from the standpoint of recent environmental conditions were normally distributed. Distributions were not normal when recent heterogeneous environmental conditions existed.

Higher titers were more often found among the frostbite group. When, however, the control and frostbite groups were adjusted for type of Korean environment from which they came the titer differences were not impressive.

One might postulate that only the few individuals having titers of 1:4 or less had resistance to frostbite as suggested by a trend of low incidence of such low titers among cold injured patients.

Studies indicated that potent "normal" cold hemagglutinins had narrow thermal amplitudes. The rewarming thermal amplitudes were, however, higher than the cooling amplitudes. This disparity in cold hemagglutination was discussed with respect to the rewarming phase of frostbite, i.e. the advisability of rapid rewarming.

In this study the degree of cold hemagglutination had no practical value in the classification or prognosis of the frostbite. It is doubtful if cold hemagglutinin tests could be used as a screening procedure for detecting individuals who might be susceptible to injury by cold.

O. The Significance of Sickling Trait in Negro Frostbite Casualties (See Section XIV)

The incidence of sickling traits among 179 Negro frostbite patients did not differ significantly from the expected incidence in an average United States Negro population. There was no relationship between the sickling trait and severity of frostbite among the Negro patients. The healing of third degree frostbite lesions was not influenced by the presence of a sickling trait in the patient. No relationship between cold hemagglutinin titers and sickling trait was established.

P. Protein Studies on Frostbite Patients (See Section XV)

A serum protein study was conducted on 262 patients with frostbite. The serum protein fractions of all frostbite casualties were within normal limits. The serum protein level of Negro frostbite patients was significantly higher than that of White patients. The fourth degree frostbite patients had significantly lower albumin and higher alpha and gamma globulin levels than the less severely frostbitten patients. The reason for this variation remains obscure. The sera of frostbite patients with a low normal protein value had correspondingly low ascorbic acid levels. The total protein content of the vesicle fluid from second and third degree frostbite was generally lower than that of the corresponding blood serum.

V. DISCUSSION

A. Preventive Aspects

Troops must be taught that COLD and IMMOBILIZATION are the two primary causative factors in the production of cold injuries, i.e. to frostbite.

1. Weather

Man has no control over weather conditions but familiarity with meteorologic phenomena can lead to a minimization of cold weather effects on the soldier during the active phases of combat. From the experience gained following the installation of weather stations in combat units in Korea during the winter of 1951-52 it is believed that weather information and simple weather predictions can be applied in the planning of tactical operations with regard to type of clothing to be worn, extra items of gear to be carried and fixing the duration of the given mission.

All soldiers and particularly the unit commanders of platoons, companies, battalions and regiments should be familiar with utilization of simple meteorological principles such as humidity (Dew Point), minimum temperature, windchill and ground surface condition.

Some existing weather conditions will require shortening of the exposure time of soldiers engaged in ambush patrols, outpost guard, general guard or motor movements in open vehicles despite the adequacy of furnished clothing and equipment and the purpose of such gear. This can frequently be anticipated by an appraisal of the existing weather conditions and the prediction for the ensuing 12-hour period. If a motor movement, in ambient temperature below 25° F., requires more than one hour

it should be the convoy commander's responsibility to dismount all troops hourly for 5 to 10-minute periods of physical activity. When ambient temperatures below 0° F. exist the troops should be dismounted every 30 minutes. The dismounted activity should be vigorous enough to produce adequate rewarming yet short of causing excessive sweating. In February 1951, a nonstop 6-hour open motor movement of one battalion when the ambient temperature was 10° F. resulted in 110 cases of frostbite.

Frostbite is dependent not only upon a low ambient temperature but also upon the condition of the ground surface. The decision for wearing the various types of bootgear, namely, leather combat boots, as opposed to shoepacs or insulated rubber boots should be predicated not only upon the prevailing weather and ground conditions, but also upon anticipated and predictable weather. If one unit commander in November 1951 had made the correct estimate of potential weather and ground surface conditions, he would not have subjected his troops equipped in leather combat boots to falling temperatures and wet ground surface conditions. His unit had been issued shoepacs which were left in the reserve area in the regimental supply train. This misjudgment plus a similar one in another unit contributed one-third of the total number of frostbite cases in 1951-52.

2. Immobilization

Immobilization of the soldier is a major factor that can

often be altered by the unit commander. Immobilization occurs when the soldier is pinned down by enemy fire, placed on interior guard duty, assigned to an outpost guard position, sent on ambush patrol or placed in a motor movement. A soldier is immobilized when he is unable to move about freely due to a situation beyond his immediate control or through his own neglect such as falling asleep while exposed to a low ambient temperature. The vast majority of frostbite cases occur during periods of immobilization. Modification of immobilization in a low ambient temperature can be accomplished in two ways; first, by minimizing immobility (increasing physical activity) of the troops and second, by utilizing the proper winter clothing, including foot and handgear. Movement of troops on foot that will be followed by a period of immobilization due either to enemy fire, guard duty or ambush positioning will often require a change of socks between the period of the march and the period of immobilization in order to lengthen safely the exposure period. This must be anticipated when planning the tactical operation giving consideration to the weather and ground surface conditions to be encountered. If there simple principles are not utilized the soldier may enter the period of immobilization with clothing saturated with sweat which conducts heat rapidly away from the body. The same consideration applies to the soldier who will wade a stream or possibly break through ice during the operation.

3. Body Clothing

A standard number of layers of clothing cannot be prescribed for universal wear throughout winter months. Weather changes rapidly and unit commanders must be constantly aware of these variations so as to regulate the body clothing. The basic recommendations from the Quartermaster Corps relate only to a standard weather type uniform. These recommendations were not intended to exclude unit initiative in the selection of clothing as weather changes occur. The decision to put on or take off certain items of clothing should not be army-wide with respect to time. Flexibility must be provided for local conditions. Certain basic principles regarding the layers of body clothing are frequently overlooked or neglected. This includes the ventilation of the body during physical activity, cleanliness of clothing to prevent loss of insulation and the avoidance of constriction, such as produced by snug fitting boots, underwear, sweaters, jackets and trousers. This also includes the securing of trouser legs be means of rubber bands or lacing the top of boots too tightly.

It is recommended that all soldiers within the regimental combat zone be equipped with the insulated rubber combat boot. All other soldiers outside this zone of combat should be issued the shoepac. The proper fitting of bootgear, especially the insulated boot, is most important. The responsibility for proper fit should rest directly

with the platoon and company commanders who must prevent individual "swapping" after issue of the bootgear.

Emphasis should be placed on the use of a single pair of wool cushion sole socks with the insulated rubber boot. Any other combinations of socks are constricting to the feet. Many wrong combinations of sockgear are worn with the shoepac. Twenty percent of the cases of frostbite during 1951-52 wore combinations considered either to be constrictive (12%) or provided inadequate insulation (8%).

Exchange of sockgear is important with the insulated rubber boot because of increased sweating, retention of sweat and a lowered resistance to epidermophytosis. Although sweating in this boot does not contribute to the loss of insulation, it nevertheless leads to the problem of maceration. Maceration as used here refers to the softening of the sole of the feet by the retained sweat. Trauma, produced by walking, to macerated tissues results in a denudation or loss of skin from the sole of the foot. These denuded painful feet will require a period of 5 to 10 days hospitalization.

During the winter of 1951-52, 30% of the frostbite cases did not have available the extra components of sockgear and insoles (for shoepacs only) for the required daily change. Analyses also indicated that 33% of the frostbite casualties did not comply with the directives concerning the daily exchange of sockgear and insoles. These errors occurred despite relatively static tactical situa-

tions without any disruptions of supply and command channels by enemy action.

Present directives state that sockgear and insoles will be changed at least once daily. Occasions arise when the soldier will have to wade through water or take part in strenuous physical activity with excessive sweating which will require exchange of these items in order to preserve the insulation and avoid excessive loss of heat from the extremity. These conditions may require a change of insoles and sockgear several times within a day. Unit commanders in their planning of operation should take this fact into account and institute steps in advance to provide an extra supply.

The commanders of small units (platoons and companies) should not assume that a given tactical situation will prevent the soldier from replacing his wet socks and/or insoles with dry ones. He should be able to foresee such events and direct the troops to carry this extra gear. Many of the casualties stated that they were ordered by their platoon leaders to strip themselves of all extra gear prior to a particular combat activity. Consequently many of the soldiers discarded their extra pairs of socks and/or insoles believing that they were following the order issued by the platoon leader. Subsequently during the ensuing combat operation wetting of the feet resulted from either wading through streams or by excessive sweating from vigorous physical activity. Often during the operation

these men were then positioned on an outpost guard or in ambush patrol where immobilization coupled with wet feet occurred. Such incidents usually resulted in a loss of manpower by frostbite.

There are no provisions for the immediate replacement of handgear which has become wet, torn or lost during a tactical operation. Although extra inserts are often provided, no provisions have been made for the replacement of the outer shells which frequently become wet. In addition, the operation of certain weapons and the execution of many procedures during a tactical operation, using the presently prescribed handgear necessitates removal of this gear to perform the task. It is strongly recommended that all soldiers undergo repeated supervised periods of practice in handling their weapons while wearing the complete mitten ensemble. These practice sessions should be conducted by the squad and platoon leaders throughout the winter whenever the tactical situation permits. It would be a major contribution if a type of handgear could be designed that would be impervious to moisture and yet permit dexterity. These above statements are based upon many observations during two winter campaigns in Korea. One example is the inability of the company aidman to apply dressings, administer morphine or plasma without removing his gloves. Other examples include inability to pull grenade pins, the unjamming of weapons and the manipulation of the sighting mechanism

of various weapons. Lacking handgear of the above recommended design, and in order to prevent the loss of handgear it is strongly recommended that the handgear be secured to the individual by the use of a neck cord or some other similar device.

4. Soldiers at Special Risk to Cold Injury

The five groups of soldiers who comprised the majority of frostbite casualties during the winter of 1951-52 were: the fatigue group, the racial group, the climatic group, the previous cold injured group and the negativistic group.

The fatigue group is comprised of soldiers who have been in active combat for 30 days or more without rest and are in a state of physical and mental exhaustion. The racial group is comprised of Negroes who are at six times greater risk for frostbite than the Whites. The climatic group is made up of soldiers who originate from and have spent most of their life in the warmer regions of the United States (mean minimum temperature for January above +20° F.). The previous cold injured group is comprised of soldiers who have had frostbite and/or trenchfoot. These individuals are two times at risk to further cold injury than are soldiers who have never been injured by cold. The negativistic group is made up of soldiers who have constellations of personality traits that can be classified as immaturity reactions. The negativistic trait refers to the tendency to oppose by thought or action any effort to influence one's behavior.

Squad, platoon and company commanders should be cognizant of the characteristics of each group so that during periods of cold weather they can give greater personal attention to the employment of preventive measures to these particular soldiers within their unit.

5. Training

In the first period of cold weather instruction Trench-foot and Frostbite should be clearly defined in lay terms for the soldier. A brief general description of each clinical entity should be given.

Many frostbitten soldiers this past winter stated, "I didn't realize frostbite was so serious. I could have been more careful".

Soldiers must be made to recognize frostbite as a serious injury. This may best be done by stressing the following:

a) Frostbite is more than a mere "nipping" by cold.

b) To incur a severe frostbite it is not necessary to have a solid freeze of the foot or hand.

c) Frostbite will require a long period of hospitalization. Long periods of confinement to bed, no pass privileges and no smoking until discharged are undesirable features of this hospitalization.

d) The damage caused by frostbite can result in loss of all or part of a foot or hand.

e) Frostbite will cause the injured part to be extremely sensitive to cold for many years. During cold weather the formerly frostbitten part will be cold

and painful.

The individual soldier should be taught that even during periods of immobilization he can carry on physical activity or movement without exposing himself to the enemy, thus preventing cold injury to a great extent. The individual should begin his movements long before the appearance of the warning signs of cold injury, namely, numbness and/or the sensation of cold. In order to insure that the individual is carrying on physical movement it should be the responsibility of the squad and platoon leaders to check frequently on the individuals when they are stationed on outpost duty, guard duty, riding a vehicle or any other occasion when tactically possible.

6. Command Responsibility

The chain of command for the prevention of cold injuries should work in both directions so that errors in supply, rotation of personnel or alterations in tactical operations reported by the small unit commander can receive the prompt attention of the higher echelons for corrections.

Repeated indoctrination of soldiers in the principles of prevention of cold weather injuries is mandatory. The responsibility for this indoctrination must be delegated to the squad, platoon and company commanders. The indoctrination of their troops should be instituted long before the onset of cold weather and not after the first cases of cold injury occur.

All combat units of company size or larger should have a

Cold Injury Control Officer. It should be his duty to promote the training for cold weather operations, advise unit commanders on errors in supply and utilization of personnel in tactical operations. He should investigate these causative factors in each case of cold injury within his unit.

It is mandatory that the squad leader examine the feet of his men daily. The medical corpsmen assigned to the platoon must inspect the feet of the platoon members at least three times a week. During each inspection particular attention should be paid to the combination of sockgear being worn, the cleanliness of sockgear, the sizing of the bootgear, the cleanliness of the feet and evidence of areas of constriction on the tips of the toes and along the side of the great toe, as well as at the ankle and lower calf levels. Unit commanders should not be satisfied with merely issuing the order to squad leaders to inspect the feet daily but should call upon such squad and section leaders for a report of their inspection. This can be verbal to simplify the procedure. Similarly, the demand for such reports can be carried upward through the command to the regimental level as a check on the execution of such orders which is important to the prevention of cold injury. In this fashion, deficits in supply, lack of understanding of earlier orders and other correctible conditions can come to the attention of the command.

The unit commander who runs his cases "underground"

in order to preserve or present a good record is not conserving manpower. Once a soldier has incurred a bona fide cold injury he should promptly be evacuated. Retention of this individual within the unit may upon subsequent re-exposure to cold develop an even more serious degree of injury. It is a well established fact that individuals with a mild to moderate degree of frostbite are more susceptible to cold than the uninjured individual. The already injured soldier is a distinct liability to his unit in subsequent tactical operations during cold weather.

B. Clinical Features

The earliest effects of cold were not elucidated in this study. The principle reason for this was the delay of the patient in reaching a medical installation after being injured. Therefore, still lacking is the documentation of the gross tissue changes that take place immediately after the rewarming of the injured part and up to 24 hours after injury. Until this information is obtained, recognition and proper classification of the injury remains inconsistent. No knowledge was gained on the question of amelioration of the severity of the injury by means of therapy prior to 40 hours after injury. No lessening of the severity of injury by therapy after this interval was noted.

Of necessity the clinical investigation of frostbite dealt with the later changes. The studies presented evidence of an abnormal vasomotor lability of the injured part. This

lability indicated the sensitivity of the injured part to cold which persisted for at least 180 days after injury. Re-exposure of injured extremities to cold produced varying degrees of cyanosis and pain. Another late effect of cold was manifested by an alteration in the sweat mechanism of the injured extremity. Sweat activity for the first 30 days after injury was depressed and from 60 to 120 days after injury was hyperactive. These findings supported the frequent complaint of excessive sweating by the post-frostbite patient.

C. Treatment and Disposition

The benefit of the routine management program for frostbite as used during 1950-51 and 1951-52 is well documented. Strict compliance with the program is a necessity which demands discipline of the doctors, nurses, corpsmen and patients.

The program is still hampered by the delay in institution of first aid measures immediately after injury. Traumatization or re-exposure to cold of the already injured part results in delayed healing. To prevent delay in institution of medical care better indoctrination of the infantrymen, aidmen and unit surgeons in recognition and management of frostbite is necessary.

Measures should be instituted to accomplish rapid rewarming of cold injured parts by exposure to temperatures of 70° to 80° F. Rewarming measures such as massage, exposure to an open fire or by walking should be discouraged.

No specific therapy was proven to be of benefit in promoting rapid healing of the frostbitten tissues or in decreasing the

severity of the injury when treatment was instituted on an average of 40 hours after injury.

The last phase in the management of a frostbite casualty is the disposition and future assignment in the military service. Because of the late changes produced in the neural and vascular tissues by frostbite and the increased sensitivity of the injured part to cold the following recommendations are made:

1. Confirmed cases of frostbite should be given a profile of L-3 or U-3 for a period of 5 years from time of injury.
2. Duty assignment of frostbite casualties should be governed by:
   a. No preferential duty assignment will be necessary for locales where the mean minimum temperatures are above 25° F.
   b. The duty assignment must assure no prolonged outside exposure for locales where the mean minimum temperatures are below 25° F.
   c. No personnel reprofiled because of frostbite should be assigned to locales where the mean minimum temperature is below 0° F.

APPENDIX I

CODE SHEETS AND QUESTIONNAIRES

USED FOR THE STUDY OF FROSTBITE

APPENDIX I

CODE SHEET FOR COLD INJURY

NAME:

1-4. NUMBER: [ ]

5. DIVISIONS:
   0. No data
   1. 1st Cav. Div.
   2. 1st Marine Div.
   3. 2nd Inf. Div.
   4. 3rd Inf. Div.
   5. 7th Inf. Div.
   6. 24th Inf. Div.
   7. 25th Inf. Div.
   8. Misc. 8th Army Units
   9. 45th Inf. Div.
   x. 40th Inf. Div.
   y.

6. REGIMENTS:
   0. No data
   1.)
   2.) Regiments of Divisions
   3.)
   4. 11th Marine Reg.
   5. Support Units of Division
   6. British Commonwealth Division
   7. French Inf. Bn.
   8. Ethiopian Exped. Forces
   9. Greek Inf. Bn.

7. BATTALION:
   0. No data
   1.)
   2.) Battalions of Regiments
   3.)
   4. Engineer Bns. (sep)
   5. Other separate Bns.

8-9. AGE (LAST BIRTHDAY)
   00. No data
   [ ]

10. RACE:
   0. No data
   1. White
   2. Negro
   3. Mongolian

11. RANK:
   0. No data
   1. Private
   2. Pfc
   3. Corporal
   4. Sergeant
   5. Company Grade Off.
   6. Field Grade Off.

12-13. STATE OF RESIDENCE:
   00. No data
   State No. [ ]

14. RESIDENCE:
   1. Rural
   2. Suburban
   3. City

15. DAYS IN KOREA:
   0. No data
   1. 1-30
   2. 31-60
   3. 61-90
   4. 91-120
   5. 121-150
   6. 151-180
   7. 181-210
   8. 211-240
   9. 241 and over

16. DAYS IN COMBAT:
   0. No data
   1. 0-15
   2. 16-30
   3. 31-45
   4. 46-60
   5. 61-75
   6. 76-90
   7. 91-105
   8. 106-120
   9. 121-135

17. DAYS IN COMBAT WITHOUT REST PRIOR TO COLD INJURY:
0. No data
1. 0-4
2. 5-9
3. 10-14
4. 15-19
5. 20-24
6. 25-29
7. 30-34
8. 35-39
9. 40-44

18. PREVIOUS COLD INJURY:
0. No data
1. None
2. Frostbite
3. Trenchfoot
4. Chilblains

19. HISTORY OF PREVISOUS ILLNESSES:
0. No data
1. Frequent Fevers
2. Pneumonia
3. Jaundice
4. Malaria
5. Raynaud's Syndrome
6. Hematuria
7. Syphilis
8. None

20. MONTH OF INJURY:
0. No data
1. November
2. December
3. January
4. February
5. March
6. April

21-22. DAY OF INJURY:
00. No data
No. of days ☐

23. HOUR OF ONSET OF NUMBNESS:
0. No data
1. 0000 to 0259
2. 0300 to 0559
3. 0600 to 0859
4. 0900 to 1159
5. 1200 to 1459
6. 1500 to 1759
7. 1800 to 2059
8. 2100 to 2359

24. SMOKING BEFORE FROSTBITE:
0. No data
1. None
2. 1/2 pack daily
3. 1 pack daily
4. 1 1/2 packs daily
5. 2 packs daily
6. Over 2 packs daily

25. HOW MANY HOURS BEFORE FROSTBITE DID YOU HAVE ANYTHING TO EAT:
0. No data
1. 0-6 hours
2. 7-12 hours
3. 13-18 hours
4. 19-24 hours
5. 25-48 hours
6. 49-72 hours
7. 73-96 hours
8. 97-120 hours
9. 121-144 hours
10. More than 6 days

26. WHAT DID THAT MEAL CONSIST OF:
0. No data
1. C ration
2. B ration
3. Individual food packet
4. Native food
5. Less than C Ration or individual food packet

27. WEIGHT IN KOREA (estimated by individual)
0. No data
1. No change
2. 1-5 lb. less
3. 6-10 lb. less
4. 11 or more lb. less
5. 1-5 lb. gain
6. 6-10 lb. gain
7. 11 or more lb. gain

28. FOOTGEAR:
0. No data
1. Boots, service, combat, russet
2. Boots, service, combat, 2-buckle
3. Leather boots with overshoe
4. Shoepac
5. Boots, combat, rubber, insulated
6. Boots, artic, felt
7. Boots, muklak
8. Service shoe
9. No footwear

29. EXTRA FOOTWEAR CARRIED BY INDIVIDUAL:
  0. No data
  1. Extra socks
  2. Extra socks and insoles
  3. No extra socks and no insoles
  4. Extra insoles but no extra socks
  5. Extra socks but no extra insoles

30. AVERAGE CHANGE OF SOCKS:
  0. No data
  1. Every day
  2. Every other day
  3. Every third day
  4. Every fourth day
  5. Every fifth day
  6. Every sixth day
  7. No change

31. AVERAGE CHANGE OF INSOLES:
  0. No data
  1. Every day
  2. Every other day
  3. Every third day
  4. Every fourth day
  5. Every fifth day
  6. Every sixth day
  7. Not applicable

32. SOCKWEAR WORN AT TIME OF INJURY:
  0. No data
  1. Socks, wool, cushion sole 1 pr.
  2. Socks, wool, cushion sole 2 pr.
  3. Socks, wool, ski, 1 pr.
  4. Socks, wool, ski, 2 pr.
  5. Socks, wool, ski, 3 pr.
  6. Socks, wool, cushion sole and socks wool ski
  7. No socks
  8. Combination other than item 6

33. SOCKS LAST CHANGED BEFORE FROSTBITE:
  0. No data
  1. Less than one day
  2. 1-2 days
  3. 2-3 days
  4. 3-4 days
  5. 4-5 days
  6. Over 5 days

34. CONDITION OF FEET AT TIME OF INJURY:
  0. No data
  1. Dry
  2. Wet with sweat
  3. Wet from muddy ground
  4. Wet from melted snow
  5. Wet from wading in water

35. HANDWEAR AT TIME OF INJURY:
  0. No data
  1. Mitten, shell, trigger finger, complete
  2. Mitten shell only
  3. Mitten insert only
  4. Glove, shell, leather complete
  5. Glove, shell only
  6. Glove, insert only
  7. No gloves

36. CONDITION OF HANDS AT TIME OF INJURY:
  0. No data
  1. Dry
  2. Wet from sweat
  3. Wet from water
  4. Wet from other liquids

37. GENERAL CONDITION OF PATIENT:
  0. No data
  1. Healthy
  2. Ill
  3. Injured, directly responsible for frostbite
  4. Injured, indirectly responsible for frostbite

38. LOCATION OF PATIENT DURING EXPOSURE:
  0. No data
  1. On top of ground
  2. In foxhole
  3. In vehicle
  4. In tent or building
  5. Bunker

39. ACTIVITY AT TIME OF INJURY:
   0. No data
   1. Sleeping
   2. Lying, kneeling or sitting with no movement
   3. Lying, kneeling or sitting with little movement
   4. Lying, kneeling or sitting with considerable movement
   5. Standing with no movement
   6. Standing with little movement
   7. Standing with considerable movement
   8. Walking with infrequent breaks
   9. Walking with frequent breaks

40. MIN. TEMP. DURING EXPOSURE:
   x. More than 37° F.
   y. 31°-37° F.
   0. No data
   1. 24°-30° F.
   2. 17°-23° F.
   3. 10°-16° F.
   4. 3° to 9° F.
   5. -4° to 2° F.
   6. -11° to -5° F.
   7. -18° to -12° F.
   8. -25° to -19° F.
   9. Less than -25° F.

41. AVERAGE TEMP. DURING EXPOSURE:
   x. More than 37° F.
   y. 31° to 37° F.
   0. No data
   1. 24° to 30° F.
   2. 17° to 23° F.
   3. 10° to 16° F.
   4. 3° to 9° F.
   5. -4° to 2° F.
   6. -11° to -5° F.
   7. -18° to -12° F.
   8. -25° to -19° F.
   9. Less than -25° F.

42. AVER. S WINDCHILL DURING EXPOSURE:
   x. 1825 to 1949
   y. Less than 700
   0. No data
   1. 700 to 824
   2. 825 to 949
   3. 950 to 1074
   4. 1075 to 1199
   5. 1200 to 1324
   6. 1325 to 1449
   7. 1450 to 1574
   8. 1575 to 1699
   9. 1700 to 1824

43. WEATHER TYPE:
   0. No data
   1. Clear to partly cloudy
   2. Cloudy to overcast
   3. Blowing snow, sand or dust
   4. Foggy
   5. Drizzle
   6. Raining
   7. Thunderstorm with rain or hail
   8. Sleet or freezing rain
   9. Snow

44. GROUND SURFACE CONDITION:
   0. No data
   1. Dry ground
   2. Wet ground
   3. Muddy
   4. Slushy
   5. Snow less than 2 inches
   6. Snow 3 to 5 inches
   7. Snow 6 to 8 inches
   8. Snow 9 to 11 inches
   9. Snow one foot or more

45. TERRAIN:
   0. No data
   1. Flat
   2. Valley
   3. Hill
   4. Mountain

46. DURATION OF EXPOSURE:
  0. No data
  1. 0-4 hours
  2. 4.1-8 hours
  3. 8.1-12 hours
  4. 12.1-16 hours
  5. 16.1-20 hours
  6. 20.1-24 hours
  7. 2 days
  8. 3 days
  9. Over 3 days

47. METHODS USED TO REWARM:
  0. No data
  1. Walking
  2. Fire
  3. Room temperature exposure
  4. Hot water soaks
  5. Message
  6. Snow
  7. Cold water soaks
  8. Other

48. TIME SEEN BY DOCTOR:
  0. No data
  1. Before rewarming
  2. 0-1 days after rewarming
  3. 2 days after rewarming
  4. 3 days after rewarming
  5. 4 days after rewarming
  6. 5 days after rewarming
  7. 6 days after rewarming
  8. 7-14 days after rewarming
  9. 14-21 days after rewarming

49. TIME EVACUATED:
  0. No data
  1. Before rewarming
  2. 0-1 days after rewarming
  3. 2 days after rewarming
  4. 3 days after rewarming
  5. 4 days after rewarming
  6. 5 days after rewarming
  7. 6 days after rewarming
  8. 7-14 days after rewarming
  9. 14-21 days after rewarming

50. SITE OF INJURY:
  1. One hand only
  2. One foot only
  3. Both hands
  4. Both feet
  5. One hand and one foot
  6. Both hands and both feet
  7. One hand, both feet
  8. One foot, both hands
  9. Other

51. DEGREE OF INVOLVEMENT, FEET, INITIAL:
  0. No data
  1. First
  2. Second
  3. Third
  4. Fourth
  5. I.C.C.
  6. I.C.C. and numbness
  7. None

52. SYMMETRY OF LESIONS, FEET:
  0. No data
  1. Same degree on each foot
  2. Different degree on each foot

53. SITE OF MAX. INJURY FEET:
  x. Information in Col. 54
  0. No data
  1. First toe
  2. Second toe
  3. Fifth toe
  4. First and second toes
  5. First and fifth toes
  6. First, second and fifth toes
  7. First, second and third toes
  8. First, second, third and fourth toes
  9. All toes

54. SITE OF MAX. INJURY, FEET CON'T:
   x. Information in Col. 53
   0. No data
   1. Heel
   2. All toes and heel
   3. One toe and heel
   4. Two or more toes and heel
   5. Distal third
   6. Entire foot

55. DEGREE OF INVOLVEMENT, HANDS, INITIAL:
   0. No data
   1. First
   2. Second
   3. Third
   4. Fourth
   5. None

56. SYMMETRY OF LESIONS, HANDS:
   0. No data
   1. Same degree on each hand
   2. Different degree on each hand.

57. SITE OF MAX. INJURY IF RIGHT HAND:
   0. None
   1. One fingertip
   2. Two fingertips
   3. More than two fingertips
   4. Dorsum of one finger
   5. Dorsum of two fingers
   6. Dorsum of more than two fingers

58. SITE OF MAX. INJURY IF LEFT HAND:
   0. None
   1. One fingertip
   2. Two fingertips
   3. More than two fingertips
   4. Dorsum of one finger
   5. Dorsum of two fingers
   6. Dorsum of more than two fingers

59. CHECK COLUMN

60. CLIMATIC REGION:
   0. No data
   1. Region I
   2. Region II
   3. Region III
   4. Region IV
   5. Region V

61. FINAL DIAGNOSIS, HANDS:
   0. No data
   1. First
   2. Second
   3. Third
   4. Fourth
   5. None

62. GANGRENE, 4th DEGREE:
   0. No data
   1. None
   2. Dry
   3. Wet

63-64. VESICLES DRIED:
   00. No data
   No. of days ☐

65-66-67. LESIONS HEALED
   000. No data
   No. of days ☐

68. RIGHT FOOT, TISSUE LOSS:
   x. One toe only, indicate
   y. All toes only
   0. None
   1. Great toe
   2. Second toe
   3. Third toe
   4. Fourth toe
   5. Fifth toe
   6. 1st & 2nd toes
   7. Distal third
   8. Heel
   9. Entire foot

69. LEFT FOOT, TISSUE LOSS:
- x. One toe only, indicate
- y. All toes only
- 0. None
- 1. Great toe
- 2. Second toe
- 3. Third toe
- 4. Fourth toe
- 5. Fifth Toe
- 6. 1st & 2nd toes
- 7. Distal third
- 8. Heel
- 9. Entire foot

70. RIGHT HAND, TISSUE LOSS:
- x. One finger only, indicate
- 0. None
- 1. Thumb
- 2. Second finger
- 3. Third finger
- 4. Fourth finger
- 5. Fifth finger
- 6. All fingers

71. LEFT HAND, TISSUE LOSS:
- x. One finger only, indicate
- 0. None
- 1. Thumb
- 2. Second finger
- 3. Third finger
- 4. Fourth finger
- 5. Fifth finger
- 6. All fingers

72. TREATMENT:
- 0. No data
- 1. Heparin
- 2. Priscoline
- 3. Sympathetic block
- 4. Rutin
- 5. HAP
- 6. Tromexan
- 7. Hexamethonium
- 8. ACTH-Cortisone

73-74-75. DURATION OF HOSPITALIZATION:
- 000. No data
- No. of days ☐

76. DISPOSITION:
- 0. No data
- 1. General duty
- 2. Limited duty
- 3. Reconditioning Center - Limited duty
- 4. Reconditioning Center - General duty
- 5. ZI

77. FINAL DIAGNOSIS, FEET:
- 0. No data
- 1. First
- 2. Second
- 3. Third
- 4. Fourth
- 5. I.C.S.
- 6. None

78. TREATMENT INSTITUTED, HRS. AFTER REWARMING:
- 0. No data
- 1. 0-12
- 2. 12.1-24
- 3. 24.1-36
- 4. 36.1-48
- 5. 48.1-60
- 6. 60.1-72
- 7. 72.1-84
- 8. 84.1-96
- 9. More than 96.1

79. EVIDENCE OF FREEZING:
- 0. No data
- 1. Definite evidence of freezing
- 2. Only ice crystals on skin
- 3. Footgear or handgear frozen
- 4. No definite evidence of freezing

80. CARD DESIGNATOR:

BASIC QUARTERMASTER QUESTIONNAIRE FOR COLD INJURY CASUALTIES

1. Name and Rank of Casualty:____________________ ASN__________

   Organization:____________________ Duty:______________

2. Type of Cold Injury:____________________ Date Incurred:__________

3. Parts of the body involved. (feet) (hands) (face) (ears)

4. Nature of exposure when injury occurred:____________________

   ____

   ____________(Geographical Location)____________

When feet are involved.

5. Type of footgear worn at time injury occurred. (combat boots) (shoepac) Was it laced too tightly? (Yes) (No). Other circulation restrictions? (No) (Yes) What?____________________

6. Kind of socks worn: (cushion sole) (ski). Number of pair worn?_____

7. Last time socks were changed prior to injury? (___hours) (___days)

8. Last time footgear was removed prior to injury? (___hours) (___days)

9. Number of days since feet were washed (____days)

10. Did soldier carry a change of socks and insoles? (Yes) (No). If not, were socks available to him by issue or sock exchange? (Yes) (No) (Issue) (Sock Exchange)

11. What foot hygiene or other preventive measures were taken?__________

   ____

   ____

   ____

When Hands or Face is Involved

12. What type of handwear was worn: (gloves) (mittens) (None). Were wool inserts available, (Yes) (No) and being worn? (Yes) (No)

13. Type of headgear and face protection worn or used: (Pile cap) (Field cap) (Hood) (Muffler) (Cheek mask)

In All Cases

14. Was other clothing worn at the time of injury considered adequate? (Yes) (No) If not, what was needed? ________________________

____

____

15. Remarks: ____

____

____

NOTE: 1. Cross out inapplicable words and fill in blanks.

2. Submit one copy of each questionnaire to the Cold Injury Research Team, 25th Evacuation Hospital, APO 301, US Army, through the Division Surgeon weekly.

CLOTHING LIST FOR COLD INJURY CASUALTIES

NAME: ______________________ RANK: __________

ORGANIZATION: ______________________

DATE OF INJURY: ______________________

WEATHER DATA: ______________________

CLOTHING WORN BY THE ABOVE AT TIME OF INJURY

Undershirt, cotton, summer, sleeveless, OD
Undershirt, cotton, summer, 3/4 sleeve, white
Undershirt, wool, 50% cotton, 50% wool
Undershirt, winter, M-1950
Drawers, cotton, short, OD
Drawers, cotton, short, white
Drawers, wool, 50% cotton, 50% wool
Drawers, winter, M-1950
Shirt, flannel, olive drab, stand-up collar
Shirt, field, wool, olive green 108 (shirt-coat)
Trousers, field, wool serge, olive drab No. 33, 18 oz.
Trousers, field, wool, olive green 108
Trousers, field, cotton, olive drab
Trousers, field, cotton, M-1951
Sweater, high-neck
Jacket, field, pile, olive drab
Jacket, field, M-1943
Liner, jacket, field, M-1951
Jacket, shell, field, M-1951
Hood, jacket, field
Socks, wool, cushion sole
Socks, wool, ski
Socks, wool, heavy, OD
Socks, cotton, tan
Boots, service, combat, composition sole
Boots, combat, russet
Shoepac, 12-inch, M-1944
Boots, combat, rubber, insulated
Overshoes, arctic, M-1945
Boots, mucluk
Boots, arctic, felt
Socks, felt
Jacket, field, wool, OD
Poncho, lightweight, OD
Overcoat, parka type, with pile liner
Parka, field, cotton with pile liner
Jacket and Trousers HBT
Cap, field, cotton w/visor
Cap, field, pile
Other: ______________________
REMARKS: ______________________

____
QM REP. COLD INJURY TEAM

PRE-EXPOSURE QUESTIONNAIRE

RECORDER ________________

(1) NAME ________________ (Last) (First) (Middle) (2) DATE OF EXAM ____________

(3) AGE ____________ (4) RACE [W] [N] [M]

(5) LOCATION ________________________

a. Rest Area [ ] b. Repo Depo [ ] c. R & R Airfield [ ]

(6) SERIAL NO. __________ (7) RANK __________ (8) MOS ________

(9) PLACE OF BIRTH ____________ (10) DATE OF BIRTH __________

(11) OTHER PLACES LIVED IN FOR AT LEAST ONE WINTER SEASON: __________

____

____

(12) TYPE OF AREA LIVED IN FOR GREATER PART OF LIFE:

a. City [ ] b. Suburban [ ] c. Rural [ ]

(13) COLDEST TEMPERATURE TO WHICH EXPOSED:

a. Approx. Temp. °F. ______ b. Approx. Length of Time ____

c. Environment: Indoors Mostly [ ] Outdoors Mostly [ ]

(14) CIVILIAN OCCUPATION ________________________

(15) SMOKING: PIPES [0] [1-3] [4-6] [7-9] [MORE THAN 10 BOWLS] (per day)

CIGARS [0] [1-2] [3-4] [5-6] [MORE THAN 6] (per day)

CIGARETTES [0] [1/2] [1] [2] [3] [MORE THAN 3] (Packs per day)

(16) TOBACCO CHEWING: (Plugs) [0] [1-2] [3-4] [5-6] [MORE THAN 7] (per week)

(17) COFFEE: (Cups per Day) [0] [1-3] [4-6] [7-9] [10-12] [OVER 12]

(18) BEER INTAKE PER WEEK, (Bottles) [0] [1-2] [3-4] [5-6] [7-8] [OVER 8]

(19) COMBAT EXPERIENCE: [YES] [NO]

a. WHEN ________________ b. WHERE ________________

(20) COLD INJURY: (Frostbite, Chilblains, Trenchfoot, etc.) [Yes] [No]

a. Anatomical Site ______________________________

b. When Occurred ______________ c. Where Occurred __________

d. Activity at Time of Injury ______________________

(21) COLD WEATHER TRAINING: [Yes] [No]

a. When ______________ b. Where ______________

c. Type of Training: Lecture [ ] d. Amount of Instruction: [ ]

Film [ ]

Demonstration [ ]

Cold Weather Operation [ ]

Other [ ]

(22) HIGHEST SCHOOL GRADE COMPLETED: [1] [2] [3] [4] [5] [6] [7] [8] [9] [10]

[11] [12] [13] [14] [15] [16] [17] [18] [19] [20]

(23) INTELLIGENCE RATING ______________ (AGCT - Area III score)

(24) DISCIPLINARY RECORD: NO. OFFENSE SENTENCE

Company Punishment [ ]

Summary Court-Martial [ ]

Special Court-Martial [ ]

General Court-Martial [ ]

(25) DISEASES: AGE:

Malaria

Yellow Jaundice

Pneumonia

Unexplained Fever (Infectious Mononucleosis, etc.)

Tuberculosis

Syphilis

Hematuria (Red or Dark Urine)

Raynaud's Disease

(26) FEET SWEAT [LITTLE] [AVERAGE] [MUCH]

(27) DO YOU CONSIDER YOURSELF RIGHT OR LEFT HANDED? [R] [L]

(28) WHICH HAND DO YOU USE TO PULL THE TRIGGER? [R] [L]

(29) HISTORY OF ACCIDENTS (Any accident requiring medical attention such as serious sprains, broken bones, etc.)

____

____

(30) HOBBIES (Particularly outdoor activities such as camping, hunting, fishing, etc.)

____

OBSERVATIONS ON ALL PATIENTS

(1) COLD AGGLUTININ SAMPLE (10 cc.) TIME TAKEN: ______________

TITER: __________ ANALYST: __________ DATE: __________

(2) PERSONAL HYGIENE (Based on Cleanliness and Neatness, particularly feet)

EXCELLENT [ ] GOOD [ ] POOR [ ]

(3) BODY TYPE ECTOMORPH [ ] ECTO-MESO MORPH [ ]

MESOMORPH [ ] MESO-ENDO MORPH [ ] ENDO-MORPH [ ]

(4) HEIGHT: ______________ (5) WEIGHT: ______________

(6) PULSE RATE AT REST: ______________

(7) ORAL TEMPERATURE: ______________

(8) SWEAT: ______________

GROSS EXAM LIGHT [ ] MODERATE [ ] HEAVY [ ]

SKIN RESISTANCE: (Taken on Instep) [ ]

STARCH-IODINE TEST: RATING [ ]

(9) BLOOD FLOW: (Return of skin color after 10 sec. pressure on end of great toe)

SECONDS [ ]

REMARKS: ____

____

CODE SHEET FOR COLD INJURIES: (PSYCHIATRIC PHASE)

NUMBER: ______________ NAME: ____________________ RANK: __________

UNIT: ______________ RACE: W N M DATE: __________________

INSTRUCTIONS: Encircle appropriate numerals under each heading, or write in pertinent comments in spaces provided.

1. PERSONALITY AND ADJUSTMENT:

0. No data.
1. Well integrated and adjusted.
2. Neurotic personality (not incapacitated by symptoms).
3. Suggestive neurosis.
4. Overt neurosis. (Specify category)
5. Pathological personality.
6. Latent or overt psychosis.
7. Post-traumatic syndrome, organic basis.
8. Behavior disorder.

2. INTELLIGENCE (SEE AGCT RATING):

0. Definitely superior.
1. Average or above.
2. Below average, not deficient.
3. Definitely deficient (moron or below).

3. EDUCATIONAL LEVEL:

0. No data.
1. Grades 1-4.
2. Grades 5-6.
3. Grades 7-8.
4. Grades 9-11.
5. High school graduate.
6. Beyond high school.

4. HISTORY OF ACCIDENTAL INJURIES:

0. No data.
1. None.
2. 1 to 3.
3. 4 to 5.
4. 6 to 7.
5. 8 to 9.
6. 10 or more.

5. EVIDENCE OF PREDISPOSITION TO INJURY:

0. No data.
1. Very little
2. Some indications.
3. Strong trends.
4. Clear-cut evidence.

6. SELF-INFLICTED COLD INJURY:

0. No data.
1. Absolutely no indication.
2. Suggestive elements present.
3. Suspect possibility.
4. Definite indications.
5. Admission of intent.

7. REACTION TO STRESS:

0. No data.
1. Very low threshold tolerance.
2. Low tolerance; avoidance of stress.
3. Moderate degree of tolerance.
4. Strong degree of tolerance.
5. Very strong degree of tolerance.

8. PERSONALITY COMPONENTS:

0. No data.
1. Markedly dependent.
2. Readily accepts authority figures.
3. Passively agressive toward authority figures.
4. Normal range of dependency feelings.
5. Strong parental ties.
6. Strong hostility feelings toward others.
7. Strong hostility feelings toward self.
8. Normal range of hostility feelings.
9. Long-range pattern of somatic preoccupation.
10. Essentially normal personality pattern.

9. SENTENCE COMPLETION TEST FINDINGS:

0. No data.
1. Dependency: ______________________
2. Fears: ______________________
3. Dominant drives: ______________________

4. Causes of own aggression: ______

5. Reactions to failure: ______

6. Reactions to authority: ______

7. ______

10. MMPI RATINGS:

INSTRUCTIONS: Mark ratings exceeding T score of 54. Place appropriate numeral (using 1 for highest rating) after proper category. Then, underline any categories below T score of 46.

0. No data.

1. Hs: ______

2. D: ______

3. Hy: ______

4. Pd: ______

5. Mf: ______

6. Pa: ______

7. Pt: ______

8. Sc: ______

9. Ma: ______

11. TAT FACTORS (MARK 3 STRONGEST TRENDS):

0. No data.
1. Depression.
2. Dependency.
3. Repressed aggression.
4. Aggression toward authority figures.

5. ______

6. ______

7. ______

12. REMARKS: ______

ARMY MEDICAL RESEARCH LABORATORY

FORT KNOX, KENTUCKY

REPORT NO. 113
1 April 1953

COLD INJURY - KOREA 1951-52*

Section I
A METEOROLOGICAL EVALUATION, KOREA, 1951-52

*Subtask under Environmental Physiology, AMRL Project No. 6-64-12-028, Subtask (8K), Cold Injury Studies.

MEDICAL RESEARCH AND DEVELOPMENT BOARD
OFFICE OF THE SURGEON GENERAL
DEPARTMENT OF THE ARMY

RESTRICTED
Security Information

SECTION I

A METEOROLOGICAL EVALUATION
KOREA, 1951-52

by

Captain Norman Sissenwine
Air Weather Service
USAF

RESTRICTED
Security Information

TABLE OF CONTENTS

RESTRICTED
Security Information

RESTRICTED
Security Information

RESTRICTED
Security Information

TABLE OF CONTENTS (cont.)

RESTRICTED
Security Information

A METEOROLOGICAL EVALUATION

KOREA, 1951-52

I. INTRODUCTION

Weather observations and awareness of the meteorological components are necessary for such decisions as the wearing of suitable types of protective clothing, length of combat missions, duration of inactivity, requirements of shelter and diet and the possible selection of cold-resistant individuals. Awareness of weather may contribute materially to the prevention of cold injury. Furthermore, to make assessments of the causative factors in frostbite such as inadequacy of clothing and equipment, activity of the individual soldier and his resistance to cold, it is necessary to know the exact climatological conditions that existed during the period when cold injuries were prevalent. Possessing a complete documentation of meteorological conditions in a cold-weather combat zone such as ambient temperatures, windchill (1), type of weather, condition of ground surface, humidity and type of terrain one may determine the physical limitation within the sphere of activity. These data might also be applied for future predictions of incidence of cold weather casualties in combat areas where the exact climatic conditions are known.

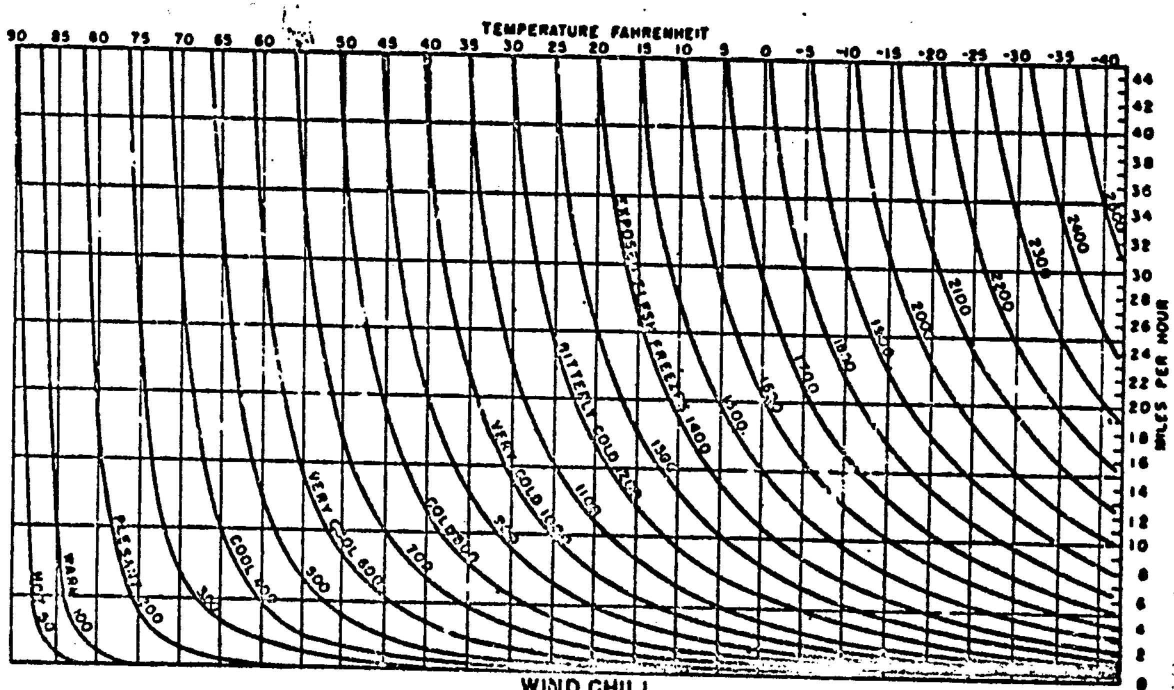
Windchill (Figure 1) is defined as the amount of heat that would be lost in an hour from a square meter of bare skin surface which has a normal temperature of 91.4° F. As a practical application it may be noted that the sensation "Bitterly Cold" indicated for -3° F. with a 5 mph wind speed is also felt at 25° F. with a 25 mph wind speed. The

designated units of the windchill chart (Kg. cal/M^{2}hr.) do not indicate quantitatively the heat withdrawn from a clothed man (2). However a more recent report (3) has shown that the windchill values given in Figure 1 are 15 times greater than actually are lost from a man dressed in arctic clothing facing into the wind.

II. PROCEDURE

Because of the vast climatic differences that occur over short distances in terrain as rugged as that of Korea it was decided that the collection of a complete series of environmental data was required at each regimental command post (generally within a few miles of actual combat) with supplemental data of temperature and surface conditions from each of the 3 battalion command posts (usually within 1 mile of the Main Line of Resistance) in the regiment. During the winter of 1951-52 weather stations were established in 22 regiments and 66 battalions. Due to frequent movement of these units and rotation of their weather personnel only 80% of the weather stations submitted weather data on any one day.

The program, officially initiated 14 November 1951 by a command letter issued from Eighth Army Headquarters (Appendix I), was concerned primarily with the meteorological factors determining the rate of body cooling (Appendix I). These factors included temperature, wind, humidity, weather and condition of the earth's surface. All these climatological conditions were recorded every three hours by each United States regiment (Appendix I). Supplemental data were collected every 6 hours from each infantry battalion (Appendix I). The total time required to obtain and record weather data was "40 man-minutes" per day at the regimental level and "8 man-minutes" at the battalion level.



WIND CHILL

NOMOGRAM OF DRY-SHADE ATMOSPHERIC COOLING

FIGURE 1. COOLING IS EXPRESSED IN KILOGRAM CALORIES PER SQUARE METER HOUR FOR VARIOUS TEMPERATURES AND WIND VELOCITIES. THE COOLING RATE IS BASED UPON A BODY AT A NEUTRAL SKIN TEMPERATURE OF 33°C. (91.4 F.) WHEN DRY COOLING RATE IS LESS THAN THE RATE OF BODY HEAT PRODUCTION. EXCESS HEAT IS REMOVED BY VAPORIZATION. UNDER CONDITIONS OF BRIGHT SUNSHINE COOLING IS REDUCED BY ABOUT 200 CALORIES. EXPRESSIONS OF RELATIVE COMFORT ARE BASED UPON AN INDIVIDUAL IN A STATE OF INACTIVITY.

Each regiment and battalion was provided with a weather kit by the Cold Injury Team (Appendix A). The kits included all the necessary instruments, written instructions and forms needed for a regiment and its 3 battalions. Personal instructions were given to the appointed weather personnel by the team Meteorologist, who toured the front, late in the fall, or when new units arrived in Korea during the winter. Retraining was required occasionally due to the rotation of key personnel.

III. RECEPTION OF PROGRAM

Even before the weather observations were initiated it was realized that the data gathered could be utilized by the regimental staffs in order to increase operational efficiency and prevent cold injury. The application of weather data to military problems was discussed with members of the regimental staffs and the men who had been selected to make the weather observations. These applications of weather data were formalized in an official Eighth Army letter entitled "Application of Weather Data to Local Operational Problems" (Appendix I). Also included with the letter was a windchill graph and psychrometric tables which were used to determine the cooling effect of the ambient temperature and wind speed and the ensuing expected morning temperature. In addition, an Air Weather Service report, "Korean Weather Throughout the Year", was furnished each regiment in order to assist in local operational planning.

A continuous exchange of letters and notes between the front-line weather stations and the Korean Cold Injury Center kept the program active. These interchanges of ideas laid the groundwork for an improved Weather Service for the Army. A letter from the meteorologist

of the Cold Injury Team maintained: "The state of the weather is as vital to the man in the bunker or tank as it is to the crew of an aircraft. As the science of weather is further developed it is possible to foresee special forecasts for operations as small as squad patrols before which the men will be briefed on the weather and ground conditions expected and the clothing and equipment required" (Appendix I). One Regimental Weather Officer, the S-2 of the 14th Infantry Regiment replied: "------ we have all units of the regiment weather conscious. We received numerous calls, sometimes numbering 20-25 daily requesting up-to-date weather information. We have publicized our station in the regimental newspaper, consequently we receive calls not only from our own regiment, but from attached units, adjacent units and at times units on division level. Fourthly, our battalions have set up individual stations and are maintaining elaborate weather charts showing weather and temperature since 1 December 1951. We have used the weather information gained for many purposes. Mainly we have used the information for planning purposes - patrols, raids, ambushes, etc. I would like to recommend that, in the event a weather study is conducted in 1952-53, thermometers be furnished in sufficient quantity to allow company weather men to be appointed to maintain hourly weather changes in each company locality. I believe the additional cost would be overshadowed by the additional information gained and the additional interest displayed" (Appendix I). This same regiment at a later date submitted a qualitative operational report on the effect of minimum temperatures it had experienced during the winter months of 1951-52 (Appendix I). This report referred specifically to the use of fuel for heating tents,

and the operation of motor vehicles and flame throwers.

Official forecasts for ground operations were made daily from an Air Force Weather Center. For any locality with rugged terrain it is difficult to forecast weather when the exact conditions of the preceding 24 hours are not known. Air Weather Service forecasters assisted by the team meteorologist arranged for a daily transmission of weather observations from the front-line stations. This procedure resulted in an increased accuracy of forecasts, especially that of expected minimum temperatures.

In January 1952 a group of Army environmental specialists made an inspection in the Korean combat zone. This group recognized the accomplishments of the new Army Weather Service. These specialists agreed that definitive steps should be taken to keep the program active after departure of the Army Medical Research Laboratory Cold Injury Research Team. The Preventive Medicine Section of the Office of the Eighth Army Surgeon requested weather data for the warmer months to be used in studies relating to hemorrhagic fever and insect-borne diseases. The Quartermaster Corps staff also desired weather data in relation to the study of body armor. As a result of these requests for weather data beyond the winter months Eighth Army General Staff decided to continue the program with an interim assignment of supervision to the Assistant Chief of Staff, G-2, and responsibility for operational control by the Eighth Army Signal Officer (Appendix I). A meteorologist from the Signal Corps was placed in charge of the operation on 15 March 1952 assuming responsibility from the Cold Injury Team. Pending more detailed changes it was decided to continue the weather program as previously outlined in this report.

All combat units and technical services were invited to contribute their ideas and requirements in such a weather program. The responses submitted included the following: 1) The Engineer staffs had an interest in sudden rises in river stages; 2) The Chemical Corps staffs desired information about local valley winds; 3) The infantry regimental staffs were interested in weather changes which could effect combat operations, local traffic and unit clothing requirements; 4) The Research and Development sections of the various technical services and their field teams desired data regarding field conditions under which equipment failures occurred; 5) Pilots of small Army planes desired more detailed weather information relative to front-line locations.

The Air Weather Service staff proposed the assignment of professional meteorologists to Army, Corps, and possibly lower levels in order to evaluate weather conditions in relation to ground operations and optimum usage of military equipment.

One of the most gratifying results of the 1951-52 cold injury research project was the continuation and expansion of the weather program into a semi-permanent service for the Eighth Army. Thus environmental data were utilized by the intelligence, operational and technical personnel in addition to their original usage by medical research personnel.

IV. POTENTIAL APPLICATIONS OF WEATHER DATA

Applications to be discussed in the following section are primarily concerned with cold injury research. (Other applications were indicated in the previous section.) Weather data were used by the Cold Injury Team to:

1) Determine the mathematical relationship between incidence of frostbite and weather. (Given climatic "normals" for future winter campaigns one may be able to plan the necessary medical logistic support.)

2) Determine the limitations of cold weather clothing (item and tolerance time) for various cold environments.

3) Attempt to elicit differences in effectiveness of cold weather training and unit discipline by comparing incidences of cold injury between similarly engaged units using climatic data as a controlling factor.

4) Evaluate the influence of combat activity on incidence of frostbite using climatic data as a controlling factor.

5) Ascertain reasons for the differences in incidence of frostbite between United States troops and troops of other nations, again using climatic data as a controlling factor.

6) Evaluate the influence of climatic conditions on the incidence of frostbite for the winters of 1950-51 and 1951-52 in Korea and for future normal winters in the same locale.

These applications were implemented by: 1) Case History IBM code sheet entries; 2) correlations of daily cold injuries with "front-wide" environmental conditions; 3) correlations of average monthly environmental conditions for each regiment with the monthly regimental cold injury incidence; 4) preparation of monthly maps showing the areal distribution of temperature along and south of the Main Line of Resistance for comparisons with other United Nations troops; 5) a comparison of the 1951-52 winter temperatures to those

encountered in the winter of 1950-51; and 6) an area comparison of the 1951-52 winter temperatures to the expected normal. The results of these applications may be found in the Epidemiology Section of the combined Cold Injury Team report.

A. Case History IBM Code Sheets

In order to evaluate exposure time of the soldier to extreme environmental conditions with respect to his degree of injury, type of clothing and extent of physical activity, a code sheet was prepared for each individual frostbite patient and selected control subjects (Figure 2). Entries on the code sheet were made directly from the respective regimental and battalion weather reports. For 25% of cold injuries occurring in separate or support units, data from the nearest regimental or battalion weather stations or Air Force Two-Man Weather Observing Teams (located near corps headquarters) were utilized. This was necessary since the weather program was not completely organized prior to the first occurrence of cold injury on 23 November 1951.

The minimum temperature during exposure was an average of that reported by the regimental and battalion weather stations. Average temperature was the mean of all temperatures reported during the period of time that the injury was incurred. For short periods of exposure, 0 to 4 hours, the average was generally the same as the minimum. (Windchill was determined from tables using the average wind

1. DIVISIONS:

0.
1.
2.
3.
4.
5.
6.
7.
8.
9.

2. REGIMENTS:

0.
1.
2.
3.
4.
5.
6.
7.
8.
9.

3. BATTALION:

0.
1.
2.
3.
4.
5.

4-5. DAY OF INJURY

00. No data

No. of days

6. HOUR OF ONSET OF NUMBNESS:

0. No data
1. 0000 to 0259
2. 0300 to 0559
3. 0600 to 0859
4. 0900 to 1159
5. 1200 to 1459
6. 1500 to 1759
7. 1800 to 2059
8. 2100 to 2359

7. DURATION OF EXPOSURE.

0. No data
1. 0-4 hours
2. 4.1-8 hours
3. 8.1-12 hours
4. 12.1-16 hours
5. 16.1-20 hours
6. 20.1-24 hours
7. 2 days
8. 3 days
9. Over 3 days

8. MIN. TEMP. DURING EXPOSURE:

x. More than 37°F
y. 31-37°F
0. No data
1. 24-30°F
2. 17-23°F
3. 10-16°F
4. 3 to 9°F
5. -4 to 2°F
6. -11 to -5°F
7. -18 to -12°F
8. -25 to -19°F
9. Less than -25°F

9. AVERAGE TEMP. DURING EXPOSURE:

x. More than 37°F
y. 31 to 37°F
0. No data
1. 24 to 30°F
2. 17 to 23°F
3. 10 to 16°F
4. 3 to 9°F
5. -4 to 2°F
6. -11 to -5°F
7. -18 to -12°F
8. -25 to -19°F
9. Less than -25°F

10. AVERAGE WIND CHILL DURING EXPOSURE:

x. 1825 to 1949
y. Less than 700
0. No data
1. 700 to 824
2. 825 to 949
3. 950 to 1074
4. 1075 to 1199
5. 1200 to 1324
6. 1325 to 1449
7. 1450 to 1574
8. 1575 to 1699
9. 1700 to 1824

11. WEATHER TYPE:

0. No data
1. Clear to partly cloudy
2. Cloudy to overcast
3. Blowing snow, sand or dust
4. Foggy
5. Drizzle
6. Raining
7. Thunderstorm with rain or hail
8. Sleet or freezing rain
9. Snow

12. GROUND SURFACE CONDITION:

0. No data
1. Dry ground
2. Wet ground
3. Muddy
4. Slushy
5. Snow less than 2 inches
6. Snow 3 to 5 inches
7. Snow 6 to 8 inches
8. Snow 9 to 11 inches
9. Snow one foot or more

13. TERRAIN:

0. No data
1. Flat
2. Valley
3. Hill
4. Mountain

FIG. 2. IBM CODE SHEET COLUMNS INDICATING OR PERTINENT TO ENVIRONMENTAL CONDITIONS.

speed and temperature for the exposure period.) Information relative to columns 8, 9, 10, 11, 12 and 13 was obtained directly from the regimental and battalion meteorological observations (Appendix I). The type of weather and ground surface conditions as coded in Figure 2 utilized only the most severe conditions encountered at time of injury.

B. Daily "Front-Wide" Correlations

The rate (per thousand men in combat) of cold injury along the Korean front varied significantly from day to day throughout the winter. It was influenced by the extent and type of activity, the equipment available (especially bootgear), the training and experience of the troops, etc. Probably the greatest single influencing factor was the weather. This was noticeable even before analysis of the records. A sudden increase in daily hospital admissions was an excellent "hindcast" of cold weather in the combat zone. Greater occurrence of frostbite also could be expected on the first day of a cold wave because of inadequate preparation for sudden drops in temperature.

Figure 3 shows the daily variations, throughout the winter, of the average temperature, coldest temperature and average windchill of the entire front. Daily variations for the period of 15 November through 15 December 1951 were less accurate because of a paucity of weather

RESTRICTED
Security Information

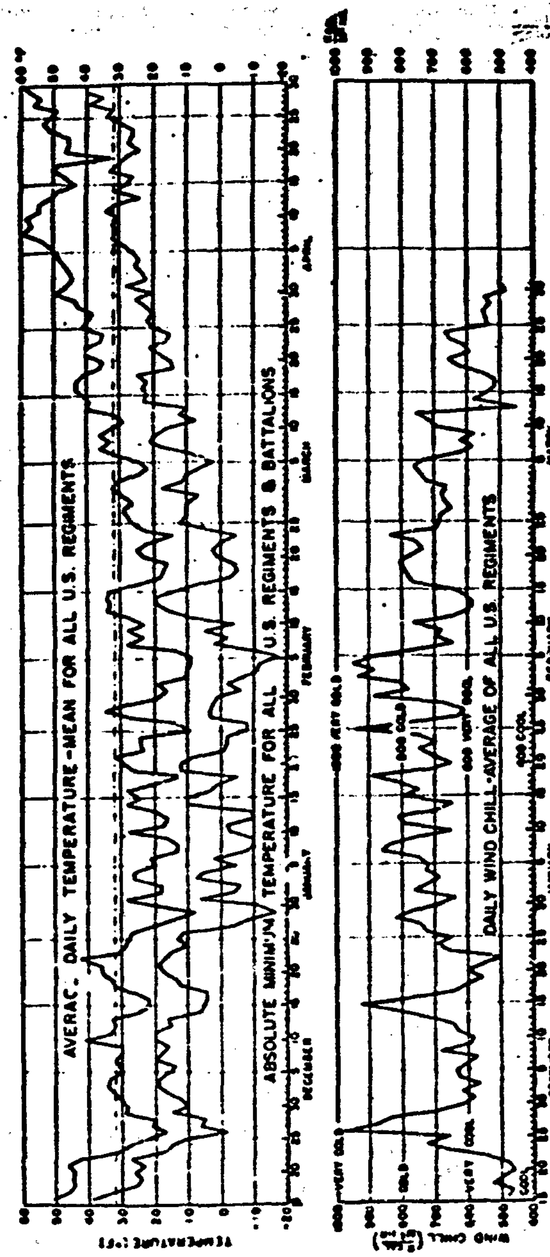


FIGURE 3. AVERAGE DAILY TEMPERATURE AND WIND CHILL AND LOWEST TEMPERATURE FOR UN FRONT

RESTRICTED
Security Information

stations in operation. More data involving the entire front were available after this time. Fortunately most of the earlier operating stations were located about the center of the front and provided information which could be considered representative of the average conditions across the Korean front. The tabulation of these data, showing the number of observations available, is given in Appendix II.

At no time during the winter did the recorded front-line temperatures reach -20° F. (Figure 3). On 29 December 1951 and 5 February 1952 temperatures of -17° and -18° F. were observed at the battalion level. Moreover, these temperatures were closely corroborated by nearby regimental stations. The 2 days indicated above had the coldest "front-wide" averages (8° and 9° F.) of any during the winter. The temperature range for all regiments on 29 December 1951 and 5 February 1952 was 2° to 17° F. and 4° to 12° F. respectively, which was enough to vary the incidence of frostbite across the front. However, it is to be noted that such temperatures are no colder than those averages found in North Dakota and Minnesota during January.

The maximum mean windchill for the winter (978 Kg. cal/M^2/hr.) occurred on 26 November 1951. The average and minimum temperatures on this day were no lower than those during January and February 1952. This extreme windchill was accompanied by the greatest daily incidence

of cold injury of the season. However, the importance of factors such as inadequate footgear, intensity of combat, duration of exposure, and degree of immobility in this incidence of frostbite have been determined in the section on Epidemiology.

C. Comparisons of Regiments

Weather conditions at any one time varied considerably along the Korean front. On 29 December, one of the coldest days of the winter, the regiments were exposed to temperatures according to the distribution in Table 1. Variations on this day between regiments in the incidence of cold injury might be expected, providing all other factors were constant. In the Epidemiology section there will appear a correlation between regimental temperatures and frostbite incidence for a comparable but longer period in February.

TABLE 1

DISTRIBUTION OF REGIMENTAL TEMPERATURES
ON 29 DECEMBER 1951

Temperature Range (°F.)	Number of Regiments	
	Minimum Temperature	*Average Temperature
16 to 20		1
11 to 15		4
6 to 10	2	5
1 to 5		3
-4 to 0	3	
-9 to -5	4	
-14 to -10	5	
-19 to -15	2	

*Three of the 16 regiments reporting minimum temperature did not have a sufficient number of reports to give a daily average on this day.

Variations between regiments became less pronounced when comparisons were made over longer periods of time. Factors contributing to the equalization of temperatures between the regiments included cloudy weather (which prevents local heating and cooling by radiation), windiness and interchange of identical locations between regiments.

A tabulation of monthly averages of environmental data for the United States Infantry regiments is given in Appendix III. Information derived from this appendix was:

1. The average December temperature of the 11 regiments (27 days of weather data required) varied from 26° to 30° F. These temperatures are comparable to those found during the coldest winter months in Central Pennsylvania, Ohio, Indiana and Illinois. The total differences between the regiments were about the same as the January differences between Toledo and Columbus, Ohio. Windchill averages for the month of December for these same 11 regiments ranged from 616 to 700 Kg.cal/M^2/hr., a little cooler than the designation "Very Cool" on the comfort scale, Figure 1. The windchill at some of the warmer stations was nearly as great as that at the colder stations. This factor in part equalized the cooling effect of the weather in different locales.
2. In January 1952 the mean monthly temperatures for 13 regiments ranged from 18.4° to 23.8° F. Such temperatures are common during January in Iowa, Northern

Illinois and Northern New York. The lowest temperatures recorded by the above regiments ranged from 2° to -10° F. One regiment reported a windchill of 1018 Kg.cal/M^2/hr. but its weather station was located on Hill 604 about 1000 ft. above all other stations.

3. In February 1952 the mean monthly temperatures for 11 regiments ranged from 21.2° to 23.0° F. Windchill for this month ranged from a low of 617 Kg.cal/M^2/hr. for the 15th Infantry Regiment located in Western Korea to 790 for the 7th Marine Regiment stationed in Eastern Korea.

4. In March 1952 the mean monthly temperatures for 16 regiments ranged from 27.3° to 40.4° F. The average windchill for this month among these regiments ranged from 499 to 904 Kg.cal/M^2/hr.

D. Areal Distribution of Temperature

Monthly maps are required in order to estimate temperatures encountered by isolated regiments and other United Nations troops when weather data were not available. Only locations for which data were available for most of the month were utilized in the construction of isotherms on these maps. Fortunately a number of the regiments occupied the same locations one or more months affording continuous data. Other regiments in exchanging command post locations initiated the gathering of data immediately thus permitting the combination of data. Also available were the data from five

Air Weather Service stations.

Figure 4 shows the geographic locations for which regimental weather data were available for one or more months. The coordinates and elevations of these locations and the weather information are included in Appendix IV. Figures 5, 6, 7 and 8 show the distribution of these data along the front.

Figure 5, showing the geographic distribution of temperature for December 1951, indicates that the coldest weather was encountered in the eastern sector of Korea. However, the difference between the eastern and central sectors of the front line was not great. Troops in the western sector, where the front extended southward, experienced warmer weather. The sharp tongue of cold air in the eastern sector may be attributed to the generally higher elevation of the terrain. This was not true for isolated high points which usually did not record the lowest temperatures due to temperature inversions. For example, Station 11, on top of Hill 604 (meters), recorded a -2° F. for the lowest January temperature as compared to -10° F. reported by nearby stations which were in valleys 400 meters below.

The modifying effect of the Yellow Sea, as it cooled during the winter, caused the axis of cold temperature to move gradually westward across the peninsula.

E. Comparison of the Winters 1950-51 and 1951-52

The total number of cold injury casualties that occurred in the winter of 1951-52 was far less than that of 1950-51.

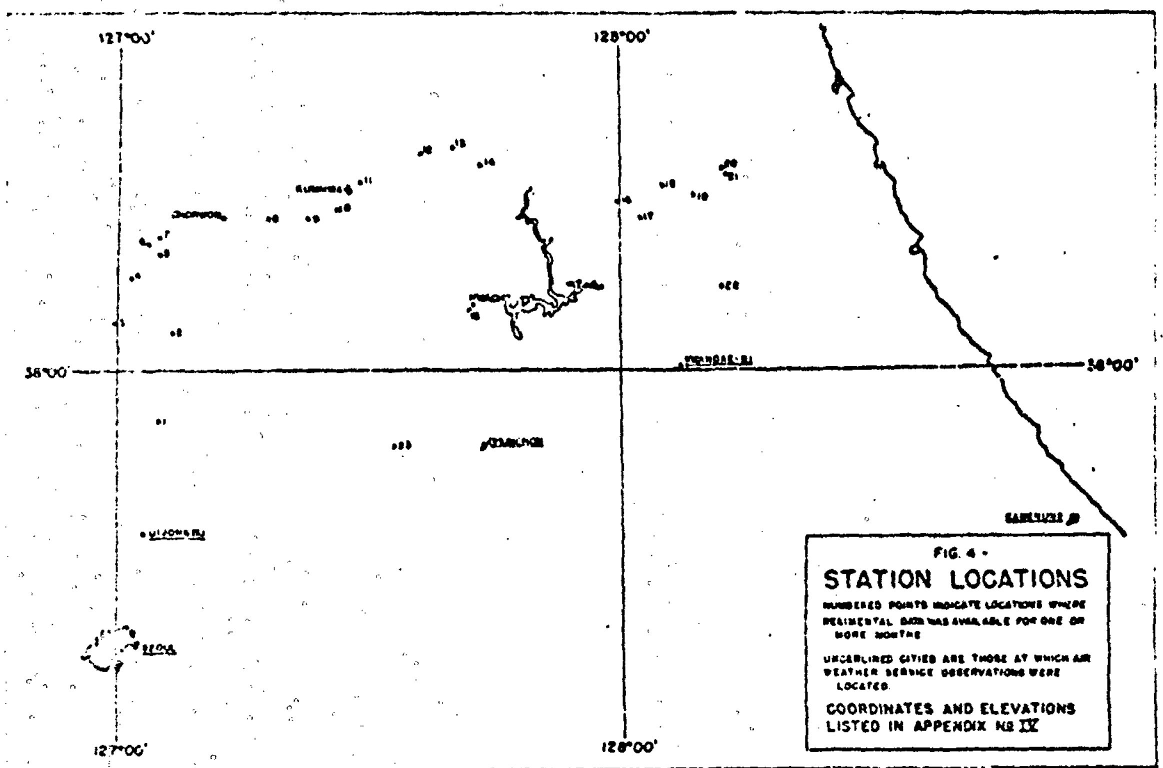
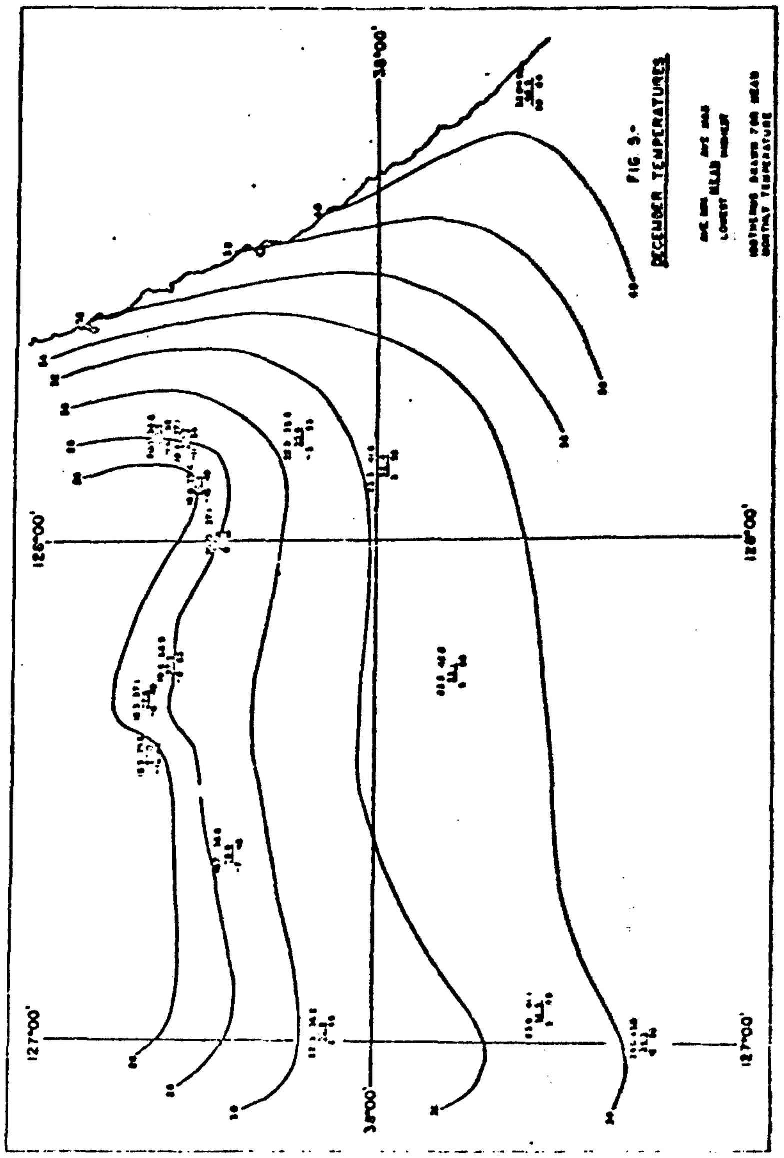


FIG. 4 -
STATION LOCATIONS
NUMBERED POINTS INDICATE LOCATIONS WHERE REGIMENTAL DATA WAS AVAILABLE FOR ONE OR MORE MONTHS
UNDERLINED CITIES ARE THOSE AT WHICH AIR WEATHER SERVICE OBSERVATIONS WERE LOCATED.
COORDINATES AND ELEVATIONS LISTED IN APPENDIX № IV

RESTRICTED
Security Information



RESTRICTED
Security Information

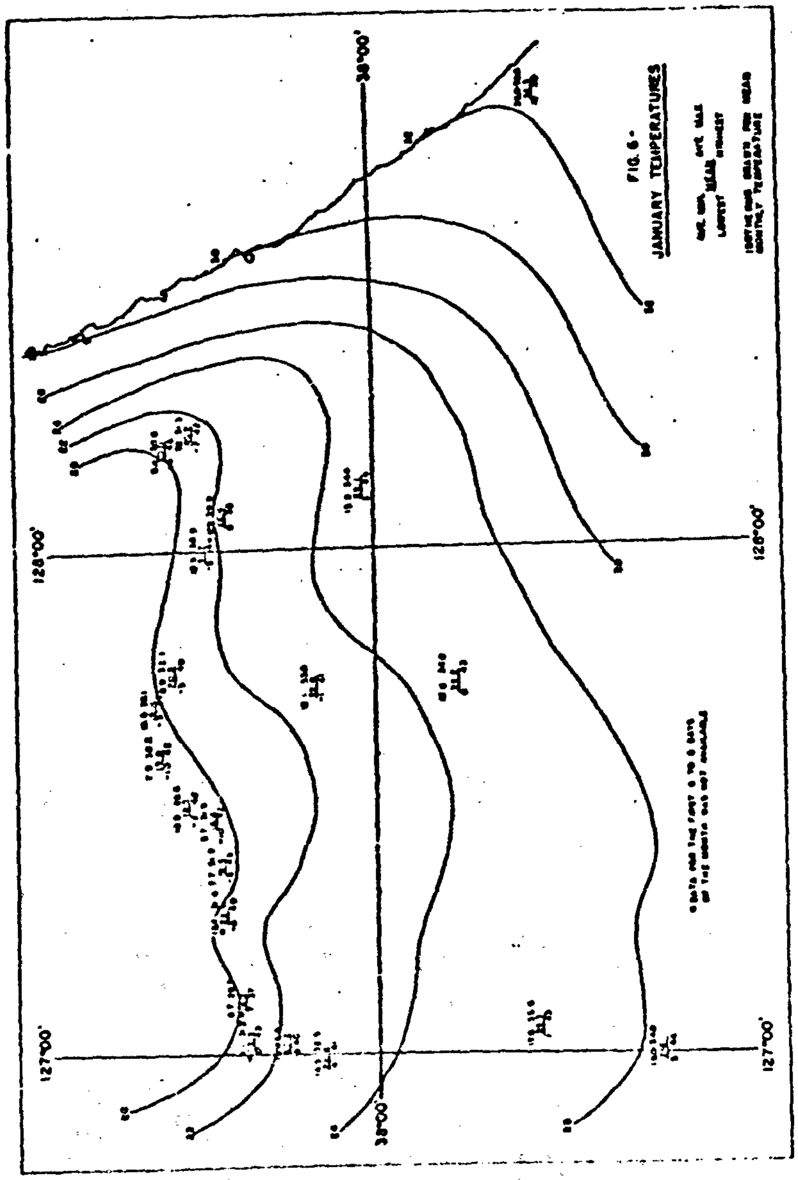
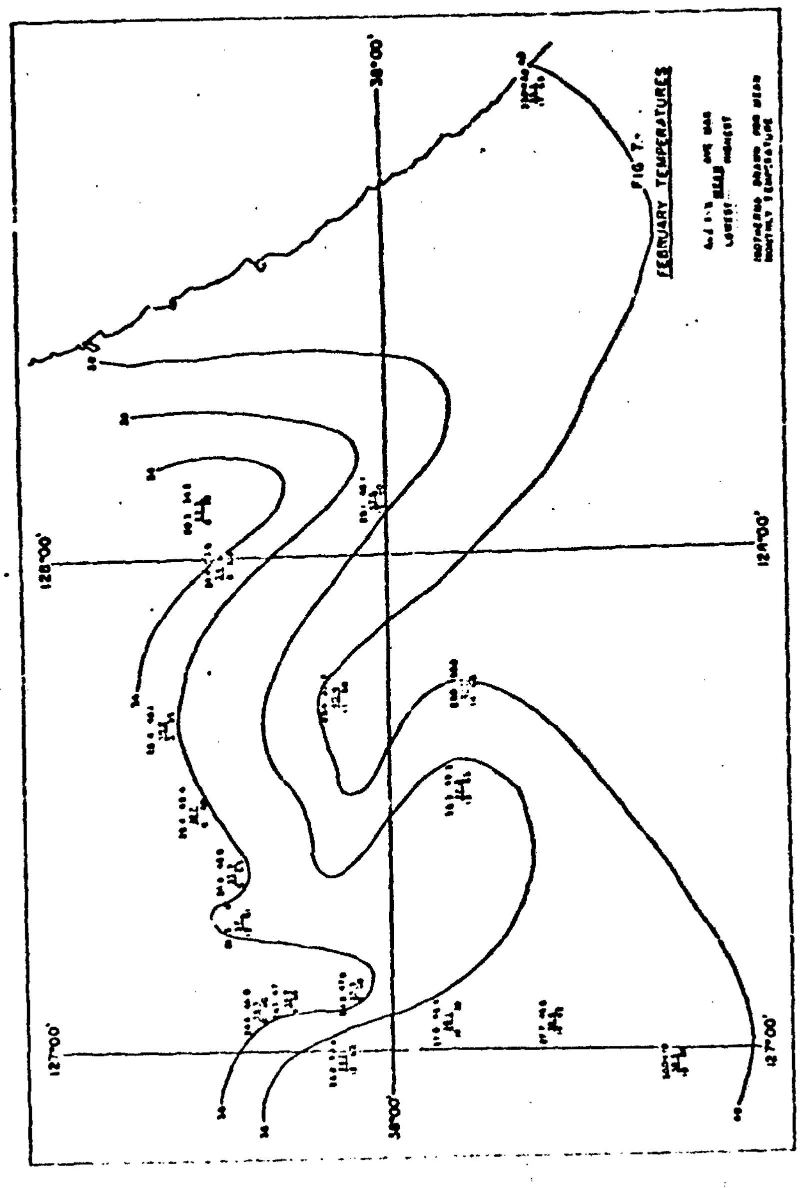


FIG. 6 -
JANUARY TEMPERATURES
38°00'
128°00'
127°00'

RESTRICTED
Security Information



RESTRICTED
Security Information

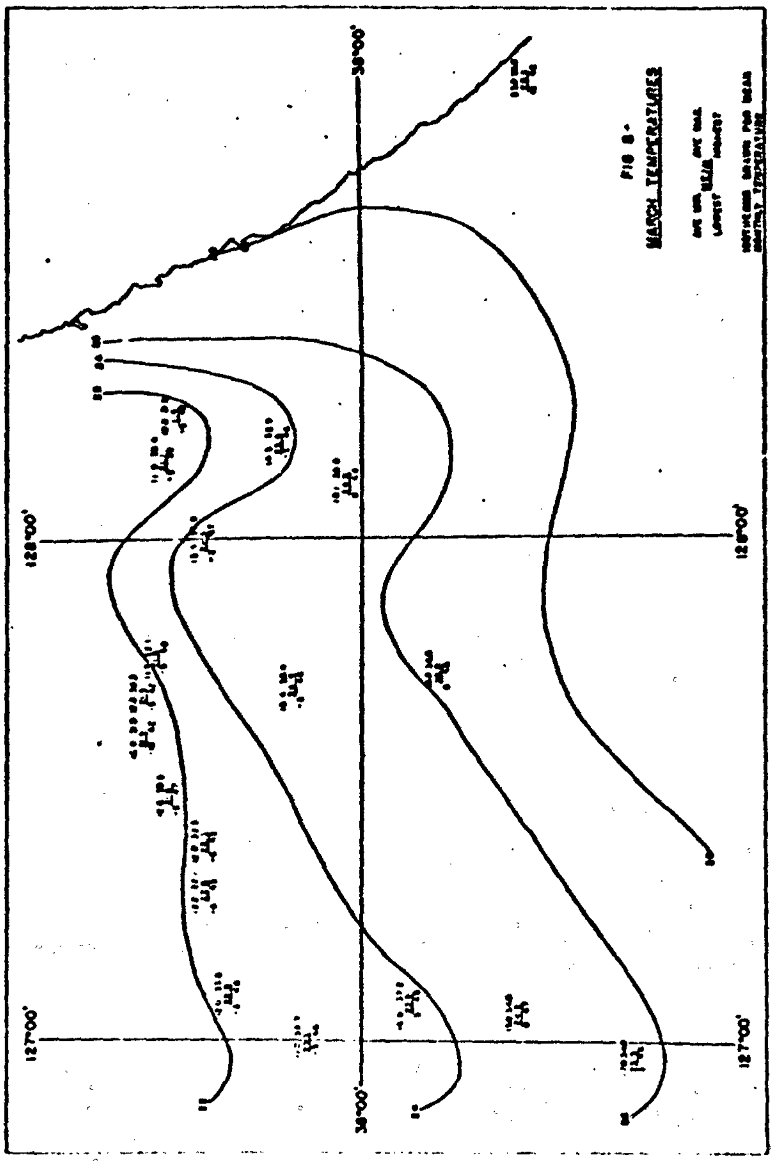


FIG 8 - MARCH TEMPERATURES

Factors responsible for the production of frostbite during the two winters included the intensity and type of combat, number of troops engaged in combat, type of bootgear and cold weather clothing used, and differences in ambient temperatures to which the troops were exposed. Temperature differences depended upon the location of the combat troops in Korea and the severity of the two winters. The picture is complicated because of factors, other than weather, mentioned above. In comparing the temperatures encountered by troops during the two winters it was possible in the Epidemiology section to speculate as to the importance of the weather factor.

Climatic data at combat level were not available for the 1950-51 winter. Temperatures encountered could be estimated best by use of monthly temperature anomalies available for the few Air Force stations in Southern Korea. These may be algebraically added to the normals. This appears to be a reasonable procedure because the Korean peninsula is small in relation to the Siberian high pressure cell, the dominant winter weather factor.

During December 1950 most of the cold injuries were incurred by United States troops while on a retrograde movement from the Yalu River and the Chosin Reservoir area in Northern Korea. Normal average December temperatures in these areas vary from 5° to 20° F. A narrow strip along the northeast coast averages 30° F. Other troops were engaged in combat at the Anju latitude in Western and Central Korea where the temperatures average 15° to 20° F. Temper-

atures were about 2° F. colder than normal in Southern Korea for this month (Table 2).

TABLE 2

AVERAGE TEMPERATURE (° F.) FOR DECEMBER 1950 and 1951
AS RECORDED BY AIR WEATHER SERVICE STATIONS IN KOREA

	AVERAGE			AVG. MINIMUM			AVG. MAXIMUM		
	'51	'50	N*	'51	'50	N*	'51	'50	N*
Chunchon	34	--	[illegible]	24	--	15	43	--	38
Kangnung	38	--	35	32	--	28	49	--	44
Kimpo	34	28	--	27	21	--	42	35	--
Seoul	34	--	28	26	--	19	43	--	36
Suwon	34	--	29	27	--	21	40	--	37
Kunsan	38	--	34	32	--	27	47	--	41
Taegu	38	32	34	28	24	25	48	40	42
Pusan	43	38	40	33	29	33	53	46	47

* N = Normal

By January 1951 the United States troops had reorganized near the 37° N. Latitude. Average monthly temperatures in this area are normally 20° to 25° F. Temperatures at Taegu and Pusan for this month were considered normal (Table 3).

TABLE 3

AVERAGE TEMPERATURE (° F.) FOR JANUARY 1951 and 1952
AS RECORDED BY AIR WEATHER SERVICE STATIONS IN KOREA

	AVERAGE			AVG. MINIMUM			AVG. MAXIMUM		
	'52	'51	N*	'52	'51	N*	'52	'51	N*
Chunchon	26	--	[illegible]	16	--	8	35	--	32
Kangnung	32	--	30	26	--	22	39	--	38
Kimpo	26	--	--	19	--	--	33	--	--
Seoul	26	--	24	18	--	15	34	--	32
Suwon	27	--	24	20	--	15	34	--	32
Kunsan	--	--	32	27	--	22	--	--	41
Taegu	32	30	30	24	22	21	41	39	39
Pusan	35	36	[illegible]	[illegible]	22	29	[illegible]	43	[illegible]

* N = Normal

By February 1951 the United States troops had moved northward to about 37° 15' N. Latitude. Normal temperatures

in this combat zone average 25° to 30° F., with slightly higher readings on the east coast. February of 1951, as indicated in Table 4 was about 4 degrees (F.) warmer than normal.

TABLE 4

AVERAGE TEMPERATURE (° F.) FOR FEBRUARY 1951 AND 1952
AS RECORDED BY AIR WEATHER SERVICE STATIONS IN KOREA

	AVERAGE			AVG. MINIMUM			AVG. MAXIMUM		
	'52	'51	N*	'52	'51	N*	'52	'51	N*
Chunchon	26	--	29	16	--	17	36	--	40
Kangnung	30	--	32	23	--	24	36	--	40
Kimpo	26	--	--	18	--	--	35	--	--
Seoul	26	--	29	17	--	20	34	--	38
Suwon	27	--	29	19	--	21	34	--	37
Kunsan	30	--	33	25	--	26	36	--	40
Taegu	32	35	33	24	29	24	40	44	42
Pusan	36	42	37	29	34	30	44	49	45

* N = Normal

By March 1951 the United States troops had moved to positions north of Seoul and Kangnung. The numerous cities in this area have long term averages of 38° F. for the month of March. The temperatures for Taegu were 5 degrees (F.) above normal while at Pusan they were normal (Table 5).

TABLE 5

AVERAGE TEMPERATURE (° F.) FOR MARCH 1951 and 1952
AS RECORDED BY AIR WEATHER SERVICE STATIONS IN KOREA

	AVERAGE			AVG. MINIMUM			AVG. MAXIMUM		
	'52	'51	N*	'52	'51	N*	'52	'51	N*
Chunchon	40	--	38	29	--	25	50	--	50
Kangnung	40	--	40	33	--	32	46	--	49
Kimpo	38	--	--	30	--	--	47	--	--
Seoul	38	--	38	30	--	29	47	--	47
Suwon	39	--	38	31	--	27	47	--	46
Kunsan	40	--	37	34	--	26	45	--	47
Taegu	43	43	38	[illegible]	33	24	52	53	52
Pusan	45	42	42	[illegible]	35	30	52	50	53

* N = Normal

As indicated previously, temperatures at combat level for the winter of 1951-52 were obtained from weather reporting units organized by the Army Medical Research Laboratory Cold Injury Team. Table 6 is a summary of the average monthly temperatures reported by the various regiments in combat.

TABLE 6

DISTRIBUTION OF AVERAGE MONTHLY REGIMENTAL TEMPERATURES IN KOREA FOR THE WINTER OF 1951-52

AVERAGE TEMPERATURE (° F.)	NUMBER OF REGIMENTS			
	DECEMBER	JANUARY	FEBRUARY	MARCH
15 to 18		1		
19 to 21		7	3	
22 to 24		9	15	
25 to 27	2	2	1	1
28 to 30	10			
31 to 33	2			1
34 to 36				8
37 to 39				8
40 to 42				1
TOTAL	14*	19**	19**	19**

* Data for 7 regiments incomplete
** Data for 2 regiments incomplete

By comparing the normal temperatures plus anomalies for the 1950-51 winter to those recorded at regimental combat levels during the 1951-52 winter, the following may be concluded:

1. December

Average temperatures to which combat troops in the Chosin Reservoir area were exposed in 1950 were about 20 degrees (F.) colder than in 1951 and similarly about

12 degrees (F.) colder at the Anju engagements. Differences in extremes were no doubt greater. The influence of weather on the 1950-51 cold injury rate was probably very considerable.

2. January

Temperatures encountered by troops in January 1951 were nearly the same as those encountered by troops somewhat further north during the warmer January 1952.

3. February

The combination of a colder month and more northerly latitude resulted in exposure of the troops during the winter 1951-52 to temperatures which averaged 7 to 8 degrees (F.) colder than 1950-51.

4. March

Both winters had temperatures that were 2 degrees (F.) warmer than the normal expected for this month, but the troops during the winter 1951-52 being located in a more northerly latitude were exposed to temperatures about 3 or 4 degrees (F.) colder than those during the winter 1950-51. However, such temperatures are only occasionally low enough to result in frostbite.

F. Normalcy of 1951-52 Korean Winter

Because of the low incidence of frostbite during the winter of 1951-52 the comparison of the monthly temperature averages with the normal monthly values attained from observations for a 10 year period were made. These data are given in Tables 2, 3, 4 and 5. Temperature anomalies, obtained from these

tables, are plotted on Figure 9.

Figure 9 shows that three of the four winter months were warmer than the expected average. Chunchon, the station closest to the combat zone and probably the most representative of conditions in that zone, showed very large positive anomalies for December and January. The difference was even more pronounced for January, the coldest month of the year, in the average minimum temperatures which was 16° instead of 8° F. (Table 3). It would appear that frostbite could have been more prevalent and more severe in a normal winter if the temperature anomalies had been in the opposite direction. Such a reversal of the temperature anomalies would have resulted in an average minimum temperature well below 0° F. instead of the 10° to 15° F. temperature encountered in 1951-52 (Appendix III).

Daily weather summaries for each United States regiment and its battalions have been prepared and are available upon request from the Army Medical Research Laboratory, Fort Knox, Kentucky. These summaries include the lowest maximum and average temperature of the day, the average wind speed and windchill, the extreme and predominant type of weather, the extreme and other types of surface conditions and the elevation of each weather station.

V. SUMMARY AND CONCLUSIONS

The procedures and techniques for collection of weather data from front-line positions in Korea were described. These data included

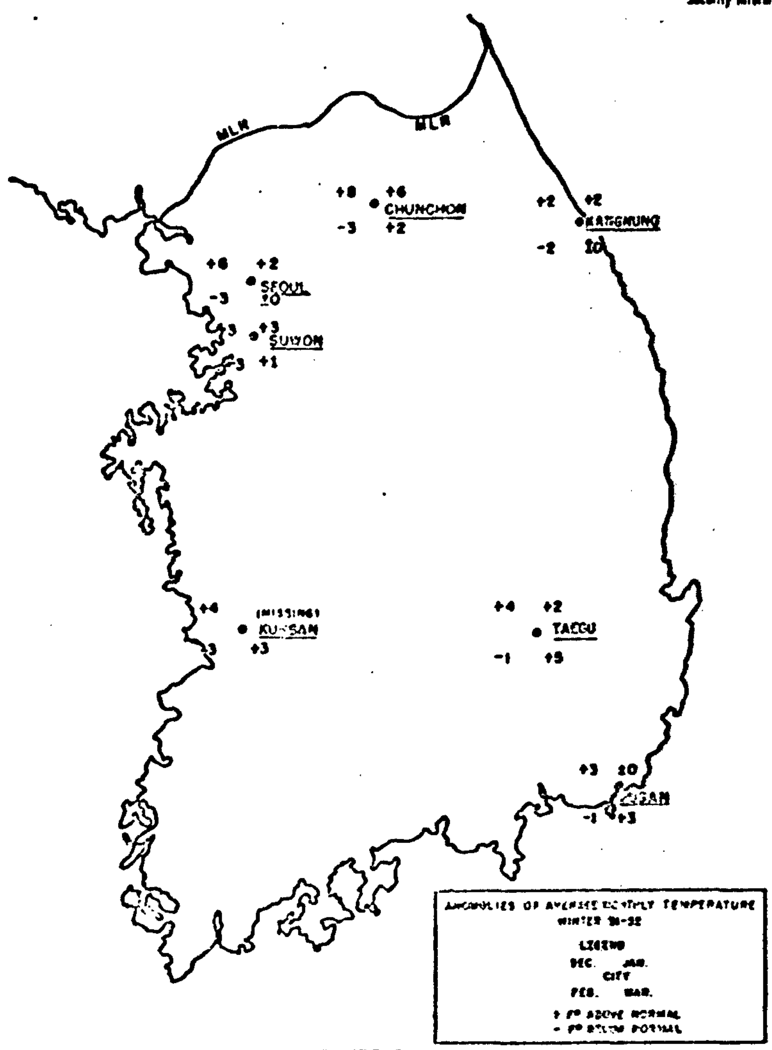

MLR
MLR
CHUNCHON
SEOUL
SUWON
KUNSAN
TAEGU
DEC. JAN.
CITY
FEB. MAR.

FIGURE 9.

RESTRICTED
Security Information

three-hourly temperatures, humidities, wind speeds (calculated wind-chill), type of weather and ground surface conditions for each United States regiment in Korea with supplemental six-hourly weather data from each of the 3 battalions in each regiment. Potential uses of these data in cold injury epidemiology were outlined and illustrated.

There have been presented comparisons of temperatures which occurred in the winters of 1950-51 and 1951-52. A further comparison was made between the observed temperatures in the winter of 1951-52 with the expected normals for the period. It was concluded that the colder temperatures experienced in December 1950 could in part account for the greater incidence of frostbite in that month as compared to the incidence in December 1951. However, January and February temperatures in 1951 and 1952 were not so dissimilar as to account for the differences in incidence of frostbite in the two years. Since the winter of 1951-52 was relatively warmer than normal it is speculatively proposed that should the temperature anomalies be reversed for another winter and all factors, including location of the combat zone, remain the same an increase in cold injury could occur.

The reception of the weather program by combat units and subsequent use by these units in their daily operations was discussed. It was indicated that an expanded weather service for the ground forces would be of definite value.

VI. BIBLIOGRAPHY

1. Siple, P. S. and C. F. Passel. Measurements of dry atmospheric cooling in sub-freezing temperatures. Proc. Am. Phil. Soc. V89, No. 1, 1945.

RESTRICTED
Security Information

RESTRICTED
Security Information

2. Breckinridge, J. R. and A. H. Woodcock. Effects of wind on insulation of arctic footgear. EPS Report No. 164, OQMG, July 1950.

3. Cermak, J. E., et al. Determination of windchill on a life-sized clothed copper man. Environmental Protection Branch, OQMC, June 1952.

RESTRICTED
Security Information

APPENDIX I

METEREOLOGICAL PROGRAM

for

COLD INJURY STUDY

KOREA, 1951-52

(True Extract Copies)

RESTRICTED
Security Information

HEADQUARTERS
EIGHTH UNITED STATES ARMY KOREA (EUSAK)
Office of the Commanding General
APO 301

AG 701 KMDA 14 November 1951

SUBJECT: Weather Observations for the Korean Cold Injury Study

TO: See Distribution

1. Effective 15 November 1951, or as soon thereafter as practicable, each infantry regiment and each infantry battalion in your command will make daily meterological observations as outlined in inclosures 1 thru 5.

2. Instruments and forms required will be furnished direct to divisions concerned. Captain Norman Sissenwine, USAF, a meteorologist, will visit commands concerned at an early date and furnish technical assistance.

3. Reports will be made daily from regiments, and every 5 days from battalions on forms (Inclosures 4 and 5) and forwarded from divisions direct to the Commanding Officer, 25th Evacuation Hospital, APO 301, (Attention: Cold Injury Research Team).

4. Reports are exempt from reports control under the provisions of par 4r, AR 305-15.

BY COMMAND OF GENERAL VAN FLEET:

(s) H. Frazier
(t) H. FRAZIER
Maj. AGC
Asst. AG

5 Incls:
1 - Instructions to Bn Weather Observers
2 - Instructions to Regt Weather Observers
3 - Meterological Program for Korean Cold Surgery Study
4 - Form, Regt Daily Meterological Observations
5 - Form, Bn Meterological Observations

DISTRIBUTION:
C.G. 1st Cav Div
C.G. 2nd Inf Div
C.G. 3rd Inf Div
C.G. 7th Inf Div
C.G. 24th Inf Div
C.G. 25th Inf Div
C.G. 1st Marine Div

INFORMATION TO:
C.G. I, IX and X Corps

RESTRICTED
Security Information

METEOROLOGICAL PROGRAM

for

KOREAN COLD INJURY STUDY
(Winter 1951-52)

(Copy of Instructions issued to all weather station personnel)

Cold injury is generally caused by excess heat loss from the entire body. The body, attempting to conserve heat for the vital inner organs, constricts blood flow to the extremities (feet and hands) resulting in their cold injury.

Cold injury may also be caused by excess heat loss from a portion of the body, invariably an extremity, even though the normal heat balance of the rest of the body is maintained. This may occur for the feet at only moderate temperatures, about freezing, following wetting, or for the hands at extremely cold temperatures by short period contact with cold soaked metallic object.

Therefore, in studying cold injury, it is important to know the magnitude of the factors causing excess general and excess local heat loss. For excess general heat loss the most important meteorological factors are air temperature and windspeed. These may be combined into a single quantitative expression of cooling power such as Wind Chill (which is the rate of heat loss from an uninsulated small cylinder having a 93° F. surface temperature), or converted to equivalent calm air temperature. Rain may also increase general cooling, especially if the soldier is without a raincoat, and will be important when encountered with temperatures near or below freezing. Other factors affecting general cooling, but not as directly and not so easily obtained and correlated, are solar radiation, outgoing radiation, and humidity.

For local cooling the most important meteorological factor is the state of the ground. It may be described simply by classifying the surface as, dry, wet, slushy, and snow of various depths. These data of surface conditions must be used in association with the air temperature to evaluate cases of local cooling. Conditions of local cooling affecting the hands are not obtained by meteorological methods, but will probably be available from case histories.

Meteorological data usually available is obtained by the Air Weather Service at Air Force Bases often quite remote from the combat zone, the scene of cold injuries. In rugged terrain, such as is encountered in Korea, the meteorological elements may vary considerably over short distances. During the past winter the coldest Air Force Base temperature on record for Korea (available at the Headquarters and the Air Weather Service) was +10° F. A two-man observation team in the support area observed -13° F. Combat troops reported having experienced -30° F. but adequate records were not maintained. Thus

it is highly important to obtain a complete set of meteorological data as close to the scene of cold injury as is possible. These data will also prove useful in evaluating the performance of all combat equipment in addition to its primary usage for Cold Injury Studies.

The following two series of observations will be obtained:

Cold Injury Meteorological Observations - Regimental

a. Where obtained - At all Regimental Headquarters (21 to 24 regiments anticipated)

b. Time of Observation - Every 3 hours (0300, 0600 - - - 2400 LST).

c. Data Required (In duplicate) - (1) Name of Regiment, its geographic location including elevation (Coordinates or reference to well-known cities may be used), and type of terrain, i.e., flat valley, hill, mountain.

(2) Exact time of observation.

(3) Dry bulb temperature (in shade) about four feet above ground.

(4) Wet bulb temperature (obtain along with dry bulb only when dry bulb is above 25° F.).

(5) Wind mileage at four feet (used to compute the average speed between observations).

(6) Weather type:
a. clear to partly cloudy
b. cloudy to overcase
c. blowing snow, sand, or dust
d. foggy
e. drizzle
f. raining
g. thunderstorm with rain or hail
h. sleet and/or freezing rain or snow
i. snowing

(7) Ground Surface Conditions:
a. dry
b. wet
c. muddy
d. slushy
e. snow, 2 inches or less
f. snow, 3 to 5 inches
g. snow, 6 to 8 inches
h. snow, 9 to 11 inches
i. snow, 1 foot or more

d. Instruments Required - (1) Signal Corps ML-24 Psychrometer with wicks and two spare thermometers.

(2) Signal Corps ML-80 anemometer with a pipe about six feet long for mounting. This pipe will be driven into the ground about two feet.

(3) Signal Corps ML-7 Thermometers (Arctic range).

Cold Injury Meteorological Observations - Battalion

a. Where obtained - At all Battalion Headquarters (63 to 72 battalion anticipated)

b. Time of Observation - Every 6 hours (0600, 1200, 1800 and 2400).

c. Data Required - (1) Name of Battalion, its geographical location including elevation (coordinates or reference to well-known cities may be used), and type of terrain, i.e., flat, valley, hill, mountain.

(2) Time of Observation.

(3) Temperature (in shade) about four feet above ground.

(4) Ground Surface Conditions:
a. dry
b. wet
c. muddy
d. slushy
e. snow, 2 inches or less
f. snow, 3 to 5 inches
g. snow, 6 to 8 inches
h. snow, 9 to 11 inches
i. snow, 1 foot or more

d. Instruments Required - Two pocket thermometers with case.

INSTRUCTIONS TO

REGIMENTAL WEATHER OBSERVATIONS

INTRODUCTION:

Knowledge of environmental conditions (weather and terrain) which you have been directed to observe and record, is extremely important to the future success of our fighting forces. Men and equipment fall victim to environmental extremes, especially to cold, wind and wetness. By knowing these extremes, reliably and exactly, it is possible to do research which, in the future, will reduce or prevent such casualties.

These data are extremely important contributions to your fellow fighting men. Accuracy is important as erroneous data can do more harm than good. A conscientious attempt must be made to obtain all scheduled observations. Only about 5 minutes every 3 hours, a total of 40 minutes a day, will be required. Scheduled time for these observations is given on the data sheets provided.

INSTRUMENTS AND USE:

Only three instruments are required, a thermometer (Signal Corps Model ML-7), a psychrometer (Signal Corps Model ML-24), and an anemometer (Signal Corps Model ML-80). These will be provided by the Korean Cold Injury Field Hospital and must be returned to that Center upon notification at the termination of this operation.

a. Thermometer (ML-7) - This is an ordinary thermometer with which you are, no doubt, familiar. It has a range of -90° F to +90° F. The temperature can be read to the nearest degree. Care must be taken to always use the minus (-) sign for temperatures below zero. Temperatures should be obtained about 4 feet above the ground, in the shade (the body may be used for shade), and away from any object which is emitting heat. The thermometer should be whirled gently on the end of a 1 foot string in order to bring it into complete equilibrium with the air. This is especially important if it has been recently removed from a heated shelter. It must be shielded from rain drops and snow flakes.

b. Psychrometer (ML-24) - This instrument is used to obtain both th air temperature and humidity. The humidity need be obtained only when the air temperature is above +25° F. The instrument consists of two thermometers attached to a metal frame to which is linked a handle. One thermometer extends out further than the other and contains a cloth sock (the wick). A reading is obtained by wetting this wick and then whirling the instrument gently by its handle for about 30 seconds. Immediately upon the discontinuation of rotation the wetted thermometer (wet bulb) is read. The instrument is then whirled again for about 10 seconds and the previous reading checked. This is repeated until two consecutive temperatures are the same. (Only 2 or 3 trials are generally

required). The other thermometer (the dry bulb) is read immediately following the final reading of the wet bulb thermometer and both readings are recorded.

When the air temperature is near freezing the wet bulb may appear to exceed the air temperature as it commences to freeze. However, after whirling for the proper period of time, the wet bulb will freeze solid and then attain a minimum temperature which will yield the correct humidity.

c. Anemometer (ML-80) - This instrument totals the miles of wind that pass by. It has a dial on it which indicates the total mileage including tenths of a mile that pass. It automatically starts over at 999.9 miles. The dial is turned by 3 cups mounted on arms. These are rotated by the wind. They must be maintained in the horizontal plane about 4 feet above the ground. The entire instrument should be mounted 50 to 100 feet away from any obstruction on a pole or pipe which has been driven into the ground about 1 to 2 feet. A thumb screw is used to tighten the anemometer onto this pipe. By knowing the exact time of two consecutive mileage observations it is possible to calculate the average wind speed during that period.

OBSERVATIONS:

Daily data sheets "Regimental, Daily Meteorological Observations, Korean Cold Injury Study" are provided for the recording of these data. The information concerning location and elevation at the top of this form is extremely important. It should be obtained from the regimental S-2. Latitude and longitude and distance and direction from nearest city should be used. When regimental headquarters are moved, a new form must always be started for the first observation at the new location.

The appropriate type of terrain to be indicated in the line beneath Location should be circled. Ordinary judgment of the observer is required. The local time, to the nearest minute should be entered in Column (2). It should correspond to the time of reading of the anemometer. The dry bulb temperature for Column (3) should be obtained from the psychrometer (ML-24) when the temperature is above +25° F. At lower temperatures either the thermometer (ML-7) which reads down to -90° F. or the psychrometer (ML-24) reading down to -35° F. may be used. Below -35° F. only the thermometer (ML-7) can be used. The minus (-) sign must be included for below zero temperatures.

The wet bulb temperature, Column (4), need be obtained only when the dry bulb is above 25° F. The instructions contained in the paragraph on the psychrometer (ML-24) in the previous section must be carefully followed as erroneous observations will otherwise be obtained.

The relative humidity, Column (5) should be omitted as it will be

calculated at the Cold Injury Hospital Center. The current mileage, Column (6) should be entered from the anemometer reading at the time indicated in Column (2). The mileage recorded for the previous observation should be included in Column (7). The speed, Column (8) and the Wind Chill, Column (9) should be left blank.

The weather type, Column (10), should be entered by choosing the most appropriate of the 9 types listed on the form. The numerical classification most applicable should be used, Column (11), surface type, should be entered in the same manner as Column (10).

DISPOSITION OF COMPLETED WEATHER FORMS

The "Regimental, Daily Meteorological Observations, Korean Cold Injury Study" form must be completed in duplicate. One copy is to be forwarded daily to the Korean Cold Injury Field Hospital, Attention: Weather Section. The Korean address will be provided under separate cover. Pertinent questions and remarks can be informally noted on the back of each form. The other copy will be kept on file with the Regiment, until completion of the program in the Spring. At that time, the entire set will be forwarded to the Cold Injury Hospital Center along with the instruments.

RESTRICTED
Security Information

REGIMENTAL
DAILY METEOROLOGICAL OBSERVATIONS

Name of Regiment:________________ Elevation:________ Meters

Location:________________ Date:________________

Type of Terrain: Flat Valley Hill Mountain (circle one)

(1) TIME Sched Local	(2) Actual Local	(3) TEMPERATURE Dry °F	(4) Wet °F	(5) Relative Humidity (%)	(6) Current	(7) WIND Previous	(8) Speed (mph)	(9) Wind chill cal/M² hr	(10) * Wea. Typ.	(11) * Surf. Typ.
0300										
0600										
0900										
1200										
1500										
1800										
2100										
2400										

WEATHER TYPE*

1. Clear and partly cloudy
2. Cloudy to overcast
3. Blowing snow, sand, or dust
4. Foggy
5. Drizzle
6. Rain
7. Thunder storms with rain or hail
8. Sleet and/or freezing rain or snow
9. Snow

SURFACE TYPE*

1. Dry
2. Wet
3. Muddy
4. Slushy
5. Snow: 2 Inches or less
6. Snow: 3 to 5 inches
7. Snow: 6 to 8 inches
8. Snow: 9 to 11 inches
9. Snow: 1 Foot or more

* Use as many classifications as are applicable

RESTRICTED
Security Information

INSTRUCTIONS TO

BATTALION WEATHER OBSERVERS

INTRODUCTION:

Knowledge of the environmental conditions (temperature and terrain) which you have been directed to observe and record, is extremely important to the future success of our fighting forces. Men and equipment fall victim to environmental extremes, especially to cold and wetness. By knowing these extremes, reliably and exactly, it is possible to do research which, in the future, will reduce or prevent such casualties.

These data are extremely important contributions to your fellow fighting men. Accuracy is important as erroneous data can do more harm than good. A conscientious attempt must be made to obtain all scheduled observations. Only about 2 minutes every 6 hours, 8 minutes a day, will be required. Scheduled time for these observations is given on the data sheet provided.

INSTRUMENTS AND USE:

Only one instrument, a pocket thermometer (Taylor Instrument Company, Model 21410, range -50 to +120° F.) is required. This and a spare will be provided by the Korean Cold Injury Field Hospital and must be returned to that Center upon the termination of this operation.

This thermometer is of a type with which you are, no doubt, familiar. Temperature can be estimated to the nearest degree from the 2 degree divisions etched on the stem. Care must be taken to always use the minus (-) sign for temperatures below zero.

The temperature should be measured about 4 feet above the ground, in the shade (the body may be used for shade), and away from any object which is emitting heat. The thermometer should be uncased and then whirled gently on the end of a 1-foot string, in order to bring it to complete equilibrium with the air. This is especially important if the thermometer has just been removed from the pocket. It must be shielded from rain drops and snow flakes.

OBSERVATIONS:

Five-day data sheets, "Battalion Meteorological Observations, Korean Cold Injury Study," are provided for the recording of these data. The information concerning location, required at the top of this form, is extremely important. Distance and direction from well-known cities and latitude and longitude should be used. It should be obtained from the Battalion S-2. A fresh form is always required for the first observation following movement of the Battalion Headquarters even though

the current form is only partially complete. The type of terrain to be indicated on the line beneath the Battalion Number should be circled. Only the ordinary judgment of the observer is required.

The date and month, Column (1) and (2) need be completed only once each day. The actual time of observation, Column (4), should be within 15 minutes of the scheduled time, Column (3), whenever possible. The temperature, as obtained by the method outlined in the previous section on Instruments and Use, should be placed in Column (5). Care must be taken to include the minus (-) sign for temperatures below zero. The proper surface type, Columns (6) through (14) should be estimated and an X placed in the column of the classification most applicable.

DISPOSITION OF COMPLETED WEATHER FORMS:

The "Battalion, Meteorological Observations Korean Cold Injury Study" forms must be completed in duplicate. One copy is to be forwarded upon completion (each five days, oftener during movement) to the Korean Cold Injury Field Hospital, Attention: Weather Section. The Korean address will be provided under separate cover. Pertinent questions and remarks can be noted informally on the back of each form.

The other copy will be kept on file with the request until the completion of the program in the spring. At that time, the entire set will be forwarded to the Korean Cold Injury Field Hospital along with the instruments.

RESTRICTED
Security Information

BATTALION
METEOROLOGICAL OBSERVATIONS

Name of Regiment: ____________ Elevation: ________ Meters

Battalion Number: ____________ Location: ____________

Type of Terrain: Flat Valley Hill Mountain (Circle one)

Date		Time		Temp	SURFACE TYPE (Check those applicable)								
Day	Mon	Sched Local	Actual Local	(°F)	Dry	Wet	Muddy	Slushy	Snow 2 in or less	Snow 3 to 5 in	Snow 6 to 8 in	Snow 9 to 11 in	Snow 1 or more feet
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
		0600											
		1200											
		1800											
		2400											
		0600											
		1200											
		1800											
		2400											
		0600											
		1200											
		1800											
		2400											
		0600											
		1200											
		1800											
		2400											
		0600											
		1200											
		1800											
		2400											

RESTRICTED
Security Information

RESTRICTED
Security Information

REGIMENTAL WEATHER OBSERVATION KIT

COMPONENTS:

a. 1 ea. thermometer ML-7 (Arctic Range).
b. 1 ea. psychrometer ML-24 w/handle
c. 2 ea. replacement thermometers for psychrometer ML-24.
d. 10 ea. replacement wicks for psychrometer ML-24.
e. 1 ea. anemometer ML-80 w/wrench, oil and instructions.
f. 1 ea. "Meteorological Program for Korean Cold Injury Study".
g. 2 ea. "Instructions to Regimental Weather Observers".
h. 100 ea. "Regimental Daily Meteorological Observations" (200 additional copies will be forwarded under separate cover.

notes;

a. A pole, pipe, or rod about 5 feet long and 3/4 inch in diameter must be obtained locally for use as the anemometer support.

b. 3 ea. Battalion Weather Observation Kits, included for forwarding, are also contained in this carton.

FINAL INSTRUCTIONS:

a. Anemometer Oiling-The anemometer ML-80 has been completely oiled with the exception of the top oil cup. It must be removed in order to add the rotating cups to the main assembly. After the oil cup has been replaced and tightened (with the wrench) its cap must be removed and the cup half filled with the light grade instrument oil provided. Care must be taken to see that one end of the cotton wick in the cup extends about 1 inch downward through the hole in the center. Monthly oilings, as indicated in the instruction manual, are required.

b. Reading the Anemometer Dial-The tens of miles are read on the scale numbered from 0 to 900 opposite the indicator line etched on the hollowed out portion of the adjacent cut cut circle. (Ten mile divisions are marked but not numbered.) The miles and tenths are then added to this first reading as the amount indicated on the outer circle by the little pointer mounted on the tiny cog wheel under the upper left rim of the dial.

MAILING INSTRUCTIONS:

Originals of the Daily Meteorological Observations form are to be dispatched as soon as completed, through channels, to:

Cold Injury Research Team,
25th Evacuation Hospital,
APO 301
c/o PM, San Francisco, Calif.
Attention: Weather Officer

RESTRICTED
Security Information

BATTALION WEATHER OBSERVATION KIT

COMPONENTS:

a. 1 ea. "Instructions to Battalion Weather Observers".

b. 2 ea. Taylor pocket thermometer (Range -50° F. to 120° F.),

c. 60 ea. "Battalion Meteorological Observations, Korean Cold Injury Study".

MAILING INSTRUCTIONS:

Originals of the meteorological forms are to be dispatched as soon as completed, through channels, to:

Cold Injury Research Team,
25th Evacuation Hospital SMBL,
APO 301
c/o PM, San Francisco, Calif.
Attention: Weather Officer

RESTRICTED
Security Information

HEADQUARTERS
EIGHTH UNITED STATES ARMY KOREA (EUSAK)
Office of the Commanding General
APO 301

AG 701 KMDA

10 January 1952

SUBJECT: Application of Weather Data to Local Operational Problems

TO: See Distribution

1. Reference letter this headquarters, AG 701 KMDA, 14 November 1951, subject; Weather Observations for the Korean Cold Injury Study.

2. The following applications of weather data to local operational problems are listed for your information:

a. Duplicates of the daily weather observations are maintained at regimental headquarters. From these it will be possible to note the exact weather conditions that existed during any operation that resulted in considerable cold injury. At some future date, when a similar action is contemplated or encountered, it will be possible to make an estimate as to the adequacy of the clothing worn by the troops by comparing the current weather data to that of the past experience. Decisions can be made as to the furnishing of additional or alternate clothing and footgear and as to the lengthening or shortening of patrols or hours of guard duty.

b. Accurate reports on the failure of weapons and equipment, because of climatic stress, can be made. Failures can be anticipated on the basis of a comparison between weather data collected during some past failure and current data. For example, the temperature below which motor vehicles will not start and recoil mechanisms malfunction can be accurately known, the wind speed at which auxiliary tie-downs are required for tentage can be determined, etc.

c. Comparisons of the cooling stress on man, under dissimilar conditions of both wind speed and temperature, can be made from the attached Wind Chill graph. For example, a temperature of -18° F. and a wind speed of 5 mph creates the same stress as -2° F. and 10 mph. (at each of these sets of conditions the exposed cheeks of an inactive soldier will quickly become hard and white.) This information may be used to supplement item a., above.

d. The minimum temperature for the next morning can be estimated from the dew point obtained from the psychrometric reading observed during the previous afternoon or evening. Unless there is a radical change in the weather pattern, usually accompanied by cloudy skies and a shift in wind direction, the morning temperature during cold weather will generally not fall more than five or six F° below the previous

RESTRICTED

AG 701 KMDA 10 January 1952
SUBJECT: Application of Weather Data to Local Operational Problems

evening's dew point. (Psychrometric tables for determining the dew point and also the relative humidity are attached. Accurate wet bulb temperatures are required. Many of those currently being forwarded are far too high, indicating insufficient whirling of the psychrometer.)

e. Temperatures and ground conditions at battalion level can be compared to those at the regimental level and to each other in order to give a clearer picture of weather closer to the actual combat.

f. These weather records will be helpful in describing the environmental conditions under which operations took place when the monthly regimental history is prepared.

g. The height of the puffy white clouds that form during sunny afternoons, of interest to air liaison officers, can be estimated by multiplying the difference between the temperature and dew point by 225. This will give the elevation, in feet, of the base of these clouds above the point of the psychrometric observation. (Accurate wet bulb temperatures are required.)

BY COMMAND OF GENERAL VAN FLEET:

(s) John F. Kolo
(t) JOHN F. KOLO
Major, AGC
Asst AG

2 Incls
1. Wind Chill Graph
2. Psychrometric tables
   a. Dew Point
   b. Relative Humidity

DISTRIBUTION
CG 2nd Inf Div
CG 3rd Inf Div
CG 7th Inf Div
CG 24th Inf Div
CG 25th Inf Div
CG 45th Inf Div
CG 1st Marine Div

INFORMATION TO:
CG I, IX and X Corps

RESTRICTED
Security Information

COLD INJURY RESEARCH TEAM
25th EVACUATION HOSPITAL
APO 301, US Army

15 January 1952

Regimental Weather Officers,
All US Regiments in Korea

Gentlemen:

The Korean cold season is about half over. Those participating in the Cold Injury Research Team's weather observing program are to be commended. With very few exceptions the weather reports received in this cold injury center have been excellent. They have helped in the anticipation of patient load in addition to their primary usage for completing the picture of conditions existing at the time of cold injury to men in your regiment.

Your headquarters has recently received a letter from Eighth Army Headquarters, Subject: Application of Weather Data to Local Operational Problems, file AG 701 KMDA, 10 January 1952, indicating 7 applications of these weather data to local operational problems. With a little thought you can probably devise numerous other applications which will make your operations more efficient and assist in preventing cold injury. Letters indicating such additions are invited in order that they may be disseminated to all regimental combat teams. The state of the weather is as vital to the man in the bunker or tank as it is to the crew of an aircraft. As the science of weather is further developed it is possible to foresee special forecasts for operations as small as squad patrols before which the men will be briefed on the weather and ground conditions expected and the clothing and equipment required.

An inspection of the regimental weather forms, a recent visit to a few of the regimental weather stations, and the reference EUSAK letter gives rise to the following notes:

a. Care should be taken to see that the oil on the anemometer is checked monthly. The oil cup on top must be maintained at least half full of oil and the cotton thread wick must be maintained in place in the main shaft.

b. A taped off regimental weather station is desirable within which the anemometer, the arctic thermometer and the psychrometer are mounted. The arctic thermometer should be attached to a board about a foot wide and 20 inches long. A block of wood about 3/4 in. of an inch thick between the thermometer and the board, at the very top is necessary in order that the air is free to circulate around the thermometer bulb. This board should be mounted on a stake so that the thermometer bulb is about 4 feet above the ground. It should be oriented east-west with the thermometer exposed to the north. In that way sunshine will not be able to reach the thermometer. A sloping shed, about 1 foot square, is desirable as a rain shield.

RESTRICTED

c. Greater care is required in keeping the psychrometer wick clean in order that it will absorb the maximum amount of water. It is suggested that the psychrometer be hung on a nail alongside the arctic thermometer and that the wick be wet from a canteen cup of water brought out for the observation. When the arctic thermometer reads below 25° F. the psychrometer need not be used.

d. It has been called to our attention that quite often more than one weather and one surface type exist. In this case all types should be listed. For example, during a sunny day mud, slush, and snow often exist concurrently. Column (11) should then be coded 3, 4, and 5. On the following night types 1 and 2 are probable indicating patches of snow and frozen ground.

e. For estimating the minimum temperature for the next day, as indicated in par. 2, d. of the referenced letter, far greater care will be required in obtaining the wet bulb temperatures than has thus far been indicated. It should never exceed the dry bulb temperatures and only equal it in a fog. Obtaining the correct wet bulb temperature often involves whirling the psychrometer for 2 or 3 minutes as (at wet bulbs below freezing) the water on the wick must be completely frozen before the wet bulb thermometer will go below 32° F. Two consecutive readings alike must be obtained before it is decided the wet bulb temperature has been reached. It must be read quickly as it will start to rise at the cessation of whirling. The hands must not be permitted to touch the thermometer tubes.

f. The dew point, required in estimating minimum temperature for the next day and also for height of the puffy white afternoon clouds (two of the operational usages indicated in the referenced letter) is obtained from the psychrometer tables for dew point. It is the number that is opposite the air temperature (dry bulb) and the depression of wet-bulb thermometer (dry bulb minus wet bulb) in one of the four tables stapled together. It will be found on only one of these tables as each table covers a different range of temperatures and depressions. This is also applicable for determining the relative humidity for which 3 similar psychrometric tables have been provided.

g. As indicated in par. 2, d. of the referenced letter, the minimum temperature for the next day in the rugged Korean terrain is usually about 5 or 6 F° colder than the late afternoon or evening dew points of the preceding day. This amount should be checked at each Regimental Weather Station by a short series of observations as it varies from location to location. This is only applicable when the skies are fairly clear of anything but puffy white afternoon clouds and their evening remnants and when the wind direction is fairly constant (as can be determined from the direction of smoke).

h. A severe cold spell often follows a period of fairly warm, cloudy, rainy, or snowy weather. Because of its sudden appearance much cold injury often results. By observing the rate of fall of dew point it is often possible to make a fairly reliable estimate of the low temperature to be expected the first clear night. If after a spell of such weather, the wind direction one morning or mid-day shifts to the west or north, the precipitation ceases, and the skies clear or are left with only low puffy or ragged white clouds the dew points should be observed carefully. Consider the following example:

Time	1200	1400	1600	1800
Temperature (°F.)	30	30	27	20
Dew Point (°F.)	28	20	13	8

An estimate of sub zero temperature for the next morning would be appropriate. The dew point is still falling and the temperature will closely approach the dew point. (On the first night following such a sequence of weather the temperature will approach but not reach the dew point. On the next night, the usual sequence of the temperature forcing the dew point down a few degrees, par. g, above, will be resumed.)

i. Obtaining an accurate dew point is often difficult at low temperatures as the wet bulb depression may be only a few degrees. For greater accuracy, both the wet and dry bulb temperatures should be observed to the nearest tenth of a degree.

j. The regimental anemometer can be electrically connected so that the instantaneous wind speed can be obtained. Knowledge of the magnitude of speed as indicated in par. 2, b, of the referenced letter, is important during high winds when tentage and other equipment are endangered. Only a simple series circuit connecting the right binding post (on the back of the dial) to the grounding binding post on the bottom of the support through a flashlight bulb and batteries is required. The number of flashes per minute is equivalent to the wind speed in mph. An on-off switch should be introduced into the circuit to lengthen the battery life.

k. All weather personnel are requested to guard carefully against the breakage of thermometers. These are currently in very short supply.

Questions concerning problems arising on the weather program are invited. Kindest regards to the men on your weather teams.

Sincerely,

(s) Norman Sissenwine
(t) NORMAN SISSENWINE
Captain USAF
Meteorologist

RESTRICTED
Security Information

HEADQUARTERS
14th INFANTRY REGIMENT
APO 25

20 January 1952

SUBJECT: Cold Weather Observation

TO: AMRL Cold Injury Team
25th Evacuation Hospital
APO 301, c/o Postmaster
San Francisco, California
Attn: Capt. Norman Sissenwine, USAF

Received your recent letter giving comments on recent inspections of Regimental Weather Stations.

I am enclosing a picture of the 14th Infantry station and a few of the major comments which I believe will assist other units in operating and maintaining a suitable weather station.

First of all, we have stimulated interest in our weather station, "The Lynx Meteorological Observation Station", by setting it up in an attractive manner and in a conspicuous place. Secondly, my chief assistant, the intelligence sergeant has taken a great interest in weather study and personally takes the regimental readings during the day; the night assistant, displaying great interest takes the required readings during the hours of darkness. Thirdly, we have all units of the Regiment weather conscious. We receive numerous calls, sometimes numbering 20-25 daily requesting up to date weather information. We have publicized our station in the Regimental Newspaper, consequently we receive calls not only from our own regiment, but from attached units, adjacent units and at times units on division level. Fourthly, our battalions have set up individual stations and are maintaining elaborate weather charts showing weather and temperature since 1 December 1951.

We have used the weather information gained for many purposes. Mainly we have used the information for planning purposes - patrols, raids, ambushes, etc. I would like to recommend that, in the event a weather study is conducted in 1952-53, thermometers be furnished to sufficient quantity to allow company weather men to be appointed to maintain hourly weather changes in each company locality. I believe the additional cost would be overshadowed by the additional information gained and the additional interest displayed.

(s) David F. Byers
(t) DAVID F. BYERS
Major, Infantry
S-2

RESTRICTED
Security Information

HEADQUARTERS
14th INFANTRY
APO 25

30 March 1952

SUBJECT: Cold Weather Observations

TO: Captain Norman Sissenwine or OIC
Signal Section, Attn: Weather Unit
EUSAK Advance
APO 301

1. In reference to my conversation with you during your last visit to our headquarters, the following list of observations obtained during the period 1 December 1951 to date are submitted:

a. At a temperature of 10°, the original diesel fuel oil used in the tent stove M 1941, became slushy. At a temperature of 3°, the diesel fuel oil became thick slush and would not flow freely into the stove generator - therefore causing many malfunctions.

b. At a temperature of -3°, vehicles were extremely difficult to start, even though they had received a complete winterization check. The 12 volt vehicle was considerably more difficult to start than the 6 volt vehicle. It was found that at temperatures of below 0°, that if vehicles were started hourly and permitted to run for a five (5) minute period, that no trouble in starting was experienced.

c. Many vehicles experienced brake trouble during temperatures of 20° and below. This was due to the vehicle at times being required to ford streams of varying depths, causing water to slosh over the brake drums and wheels. It was found that the freezing of brakes could many times be eliminated by the driver depressing the brake pedal while the vehicle continued in motion for a short distance.

d. At one time during the month of December 1951 a temperature of -10° was noted between recorded periods. While traveling through a deep defile on 17 December 1951, a temperature of -25° was noted. The low temperature that date in the Regimental area was 10°, a difference of 35°. It was also noted that in this same defile, the roads remained icy for a period of 9 days after other roads in more open areas had become clear.

e. The flame thrower M2-2, used by our units, using the napalm mixture, was effective at temperatures of -1°.

f. Maximum, Low, and Mean temperatures by month were:

	Maximum	Low	Mean
December	49°	-7°	29°
January	43°	-5°	12°
February	43°	-6°	23°
March	59°	9°	34°

(s) David F. Byers
(t) DAVID F. BYERS
Major Inf
S-2

RESTRICTED
Security Information

HEADQUARTERS
EIGHTH UNITED STATES ARMY KOREA (EUSAK)
Office of the Commanding General
APO 301

AG 000.91 KSIX

24 February 1952

SUBJECT: Change of Responsibility for Supervision of Local Weather Station Program

TO: See Distribution

1. The program establishing local weather stations for the collection of data to be used by cold weather injury teams has resulted in the incidental use of this information in planning and in operations in all echelons of this command. Reports reaching this headquarters offer substantial reasons for continuing the program until its fuller applications have been studied by higher authority and a decision reached as to whether the operation of this service should be provided for in Tables of Organization and Equipment.

2. It is therefore directed that, effective 15 March 1952, the Assistant Chief of Staff G-2 assume general staff supervision over the continuance of the weather station program to include responsibility for the dissemination of data to interested units and staff sections.

3. Effective 15 March 1952, the Signal Officer, EUSAK, is directed to assume responsibility for the operational control of the weather station program in Eighth Army, to include supervision of weather station operations, the provision of the necessary meteorological equipment, the compilation of data, and the technical training of weather observers.

4. Effective 15 March 1952, all reserve stocks of meteorological equipment now in the hands of cold weather injury teams, stock records of equipment in the hands of using troops, and such experience data as has been compiled on replacement factors for this equipment will be turned over by the cold weather injury teams to the 181st Signal Depot Company (Army).

BY COMMAND OF GENERAL VAN FLEET:

(s) David J. Reina
(t) DAVID J. REINA
Major, AGC
Asst AG

Distribution:
D & S

RESTRICTED
Security Information

RESTRICTED
Security Information

COLD INJURY RESEARCH TEAM
25th Evacuation Hospital
APO 301 U. S. Army

9 March 1952

Regimental Weather Officers
All US Regiments in Korea

Gentlemen:

The transmittal to EUSAK of daily maximum and minimum temperature and 0600 weather types is working smoothly and proving of definite planning and forecasting value. The increase in accuracy of forecasted minimum temperature has been noted by the 30th Weather Squadron forecasters and the front line installations receiving these forecasts.

Clarification is required on only one point. Frequently an improbable combination of weather types is reported. For example, code 1 and 5 or code 1 and 9 have been often noted. These indicate clear to partly cloudy skies with, in the first case drizzle, and in the second, snow. It is suspected that the code number for the surface type is being erroneously added in the morning message. Only the code for weather type or types should be included. The morning weather message should not include weather types 1 or 2 if one or more of types 5 through 9 are transmitted.

As indicated in the article "Eighth Army Keeps Weather Info File", in the 7 March 1952 Stars and Stripes, a continuation of the weather program is planned. Changes in the program itself, as well as in the TO&E are anticipated. Captain G. D. Dean, Signal Corps Meteorologist, is currently working with me in preparation for the transfer of this responsibility. You will be notified of changes as soon as possible. In the mean time you are urged to give thought and forward suggestions on the amplification of the program required in order to increase its value at regimental level. Such factors as river flood stage warnings, local trafficability forecasts, and tolerance time on ambush patrols (in cold weather) are being considered.

The past winters program has traversed a very rough Korean type road. Rotation of key personnel, instrument breakage with consequent supply problems, and lack of sufficient and trained personnel on both yours and our end of the program were some of the major bumps. However, chiefly due to your efforts, the program has proven a huge success. Please continue the good work.

My kindest regards and thanks to the men assisting on the program.

Sincerely,

(s) Norman Sissenwine
(t) NORMAN SISSENWINE
Captain USAF
Meteorologist

RESTRICTED

RESTRICTED
Security Information

APPENDIX II

DAILY AVERAGES OF TEMPERATURE AND WINDCHILL AND

LOWEST TEMPERATURE ALONG U.S. FRONT*

KOREA, 1951-52

*Regiments in reserve north of Chunchon included.

RESTRICTED
Security Information

DAILY AVERAGES
OF ENVIRONMENTAL DATA ALONG U.S. FRONT

DATE	Avg. **No.	Temp. (°F)	Lowest **No.	Temp.* (°F)	Avg. **No.	Wind Chill (K cal/M²/hr)
16 Nov.	1	56	1	39	1	480
17	1	46	1	32	1	465
18	2	44	2	26	1	522
19	2	45	2	24	2	495
20	3	44	3	26	3	461
21	4	46	4	23	4	478
22	4	42	4	27	4	545
23	5	31	5	17	5	659
24	5	28	5	15	4	724
25	5	23	6	10	4	661
26	5	17	7	-2	4	978
27	6	21	8	7	5	876
28	8	20	9	6	7	831
29	8	29	10	15	7	696
30	9	28	10	10	8	610
	--	--	--	--	--	---
1 Dec.	11	30	12	12	10	560
2	11	32	12	16	10	616
3	13	34	12	19	11	567
4	14	34	14	19	13	627
5	15	30	14	16	14	636
6	15	31	14	14	14	603
7	14	32	14	20	13	571
8	14	30	15	18	13	682
9	13	30	15	16	12	591
10	14	36	15	20	12	[illegible]
11	13	33	16	20	11	630
12	15	32	16	15	14	644
13	13	33	15	16	12	719
14	15	25	16	5	13	826
15	14	22	15	5	10	917
16	16	22	17	4	13	758
17	15	26	17	4	13	633
18	15	32	17	12	14	604
19	17	33	17	14	16	554
20	17	36	17	17	16	601
21	16	36	18	19	14	550
22	15	42	18	17	13	502
23	15	31	18	15	14	651
24	13	29	18	10	13	691
25	13	23	17	13	12	640
26	14	27	17	11	14	732
27	16	20	17	-4	15	744

*Lowest temperature recorded including all Regiments and Battalions available.
**Number of Regiments from which data was available.

DATE	Avg. **No.	Temp. (°F)	Lowest **No.	Temp.* (°F)	Avg. **No.	Wind Chill (K cal/M^2/hr)
28 Dec.	16	14	16	-9	14	813
29	13	9	16	-17	12	768
30	15	18	17	-11	14	686
31	16	28	17	6	15	635
	--	--	--	--	--	---
1 Jan.	14	18	17	-4	14	762
2	15	18	17	-6	13	724
3	16	26	17	7	14	688
4	16	26	17	5	14	723
5	16	20	18	-5	14	718
6	16	21	19	2	15	752
7	17	13	20	-8	15	857
8	18	13	20	-10	17	839
9	20	16	20	-10	19	755
10	20	28	20	-3	19	649
11	20	17	20	-2	19	795
12	20	16	20	-10	19	805
13	19	20	20	-9	18	695
14	19	28	19	10	18	645
15	18	24	19	10	17	795
16	19	28	20	3	18	748
17	17	20	20	1	17	801
18	15	12	19	-5	15	838
19	18	26	20	12	18	717
20	18	29	20	12	18	653
21	20	31	20	8	20	700
22	20	23	20	-1	20	747
23	20	24	20	-2	20	693
24	18	24	19	-2	18	743
25	17	9	19	-3	17	942
26	18	13	20	-8	18	775
27	17	28	20	3	16	625
28	19	34	20	3	18	606
29	15	28	17	2	14	674
30	17	19	20	1	17	883
31	20	16	20	-6	19	779
	--	--	--	--	--	---
1 Feb.	20	19	20	-2	20	803
2	20	10	20	-6	20	931
3	20	10	20	-11	20	885
4	19	9	20	-12	18	943
5	15	9	20	-18	15	889
6	15	14	13	-10	15	750
7	18	28	20	2	18	647
8	19	23	20	-2	19	694
9	19	28	20	5	20	682
10	18	23	18	-4	17	762
11	21	28	20	9	17	648
12	20	34	20	15	18	596
13	20	33	20	19	19	586

DATE	Avg. **No.	Temp. (°F)	Lowest **No.	Temp.* (°F)	Avg. **No.	Wind Chill (K cal/M²/hr)
14 Feb.	20	34	20	20	19	600
15	20	33	20	12	19	641
16	20	24	20	6	18	765
17	18	18	20	-3	17	780
18	19	17	20	-5	16	794
19	19	16	19	-4	17	804
20	19	23	19	1	17	773
21	16	25	19	2	14	735
22	16	22	19	0	14	759
23	17	14	19	-5	15	835
24	17	23	19	4	15	693
25	16	25	19	12	14	684
26	16	23	20	10	14	682
27	17	29	20	10	15	650
28	20	26	20	9	18	669
29	18	29	20	6	16	677
	—	—	—	—	—	—
1 Mar.	19	32	19	17	17	644
2	19	31	20	11	19	723
3	19	25	20	10	18	852
4	19	22	20	5	13	763
5	19	24	20	2	18	729
6	20	31	20	8	19	624
7	19	36	20	17	18	539
8	20	33	20	21	17	626
9	20	35	20	19	18	579
10	19	32	20	16	13	695
11	20	29	20	7	19	713
12	20	32	20	12	13	752
13	20	40	20	10	18	450
14	20	39	20	23	19	579
15	20	41	19	22	19	552
16	19	43	19	23	18	516
17	15	43	19	22	14	516
18	17	41	18	24	15	554
19	16	35	19	14	15	622
20	18	35	19	15	16	656
21	17	40	20	18	17	596
22	18	40	19	21	18	603
23	17	35	18	16	17	752
24	17	35	18	15	17	663
25	17	41	19	20	15	537
26	18	40	20	22	18	542
27	16	33	19	20	16	552
28	18	42	20	22	18	531
29	19	43	21	25	18	554
30	18	49	19	20	17	[illegible]
31	20	46	21	28	20	496

APPENDIX III

MONTHLY AVERAGES OF ENVIRONMENTAL DATA FOR

EACH UNITED STATES INFANTRY REGIMENT

KOREA, 1951-52

RESTRICTED
Security Information

MONTHLY ENVIRONMENTAL AVERAGES
FOR EACH U.S. REGIMENT

REGIMENT	Days Avail. (No.)	Lowest Temp. (°F)	Ave. Min. Temp. (°F)	Mean Temp. (°F)	Ave. Max. Temp. (°F)	Highest Temp. (°F)	Average Wind Chill (K cal/M²/hr)
			(NOVEMBER)				
1st Marines	0	-	-	-	-	-	-
5th Marines	0	-	-	-	-	-	-
7th Marines	2	18	21.0	30.0	39.0	39	-
9th Infantry	0	-	-	-	-	-	-
23rd Infantry	0	-	-	-	-	-	-
38th Infantry	0	-	-	-	-	-	-
7th Infantry	0	-	-	-	-	-	-
15th Infantry	0	-	-	-	-	-	-
65th Infantry	3	21	26.3	30.3	34.3	40	M*
17th Infantry	3	12	17.7	25.7	33.7	40	700
31st Infantry	13	7	23.8	33.0	42.3	57	629
32nd Infantry	14	7	21.4	32.5	43.6	59	639
5th Infantry	5	12	15.2	23.4	31.6	40	M
19th Infantry	4	12	16.7	26.2	35.7	42	638
21st Infantry	3	7	10.6	21.0	31.3	38	733
14th Infantry	0	-	-	-	-	-	-
27th Infantry	11	9	25.2	31.8	38.5	60	737
35th Infantry	9	10	20.8	28.0	35.2	55	784
160th Infantry	0	-	-	-	-	-	-
223rd Infantry	0	-	-	-	-	-	-
224th Infantry	0	-	-	-	-	-	-
179th Infantry	0	-	-	-	-	-	-
180th Infantry	0	-	-	-	-	-	-
279th Infantry	0	-	-	-	-	-	-
			(DECEMBER)				
1st Marines	31	-11	21.0	29.5	38.0	54	665
5th Marines	31	-1	20.4	28.5	36.6	52	693
7th Marines	27	-3	21.5	29.4	37.3	53	694
9th Infantry	28	1	21.2	28.8	36.5	46	630
23rd Infantry	26	-7	17.1	27.3	37.5	59	642
38th Infantry	3	17	19.0	31.3	43.6	45	605
7th Infantry	23	2	22.3	30.8	39.2	49	556
15th Infantry	15	10	25.5	31.2	36.8	47	627
65th Infantry	15	3	20.3	24.6	29.0	40	M
17th Infantry	31	-16	18.6	26.2	33.8	49	700
31st Infantry	29	0	21.1	30.0	38.9	50	623
32nd Infantry	31	0	20.0	28.6	37.1	51	643
5th Infantry	29	-8	18.3	27.7	37.1	49	667
19th Infantry	31	-8	19.5	28.2	36.9	53	616
21st Infantry	30	-16	15.5	26.0	36.5	47	699
14th Infantry	31	-7	18.7	29.0	38.8	49	653
27th Infantry	18	10	25.9	31.5	37.1	34	729

* M - Data Missing.

REGIMENT	Days Avail. (No.)	Lowest Temp. (°F)	Ave. Min. Temp. (°F)	Mean Temp. (°F)	Ave. Max. Temp. (°F)	Highest Temp. (°F)	Average Wind Chill (K cal/M²/hr)
(DECEMBER)							
35th Infantry	22	2	24.4	32.3	40.2	50	658
160th Infantry	0	-	-	-	-	-	-
223rd Infantry	0	-	-	-	-	-	-
224th Infantry	0	-	-	-	-	-	-
179th Infantry	0	-	-	-	-	-	-
180th Infantry	0	-	-	-	-	-	-
279th Infantry	0	-	-	-	-	-	-
(JANUARY)							
1st Marines	31	-7	9.2	20.2	31.3	39	769
5th Marines	27	-2	11.1	21.2	31.4	49	812
7th Marines	27	-4	12.5	22.0	31.5	46	790
9th Infantry	31	-9	10.9	19.8	28.6	40	1018
23rd Infantry	30	-10	5.7	18.6	31.9	42	722
38th Infantry	21	-6	13.4	22.4	31.4	40	766
7th Infantry	28	2	15.5	23.8	32.2	41	708
15th Infantry	26	-5	14.6	24.7	34.8	49	M
65th Infantry	25	-8	16.8	22.4	28.0	40	702
17th Infantry	29	-7	7.8	21.7	35.6	50	809
31st Infantry	30	-2	12.5	21.7	30.9	44	702
32nd Infantry	31	0	12.9	21.4	29.9	38	713
5th Infantry	31	-3	10.0	19.6	29.1	38	772
19th Infantry	16	-5	6.8	18.2	29.4	40	744
21st Infantry	27	-10	7.2	18.4	29.6	42	761
14th Infantry	28	-5	8.0	19.9	31.7	43	755
27th Infantry	0	-	-	-	-	-	-
35th Infantry	30	-1	12.1	22.6	33.0	41	700
160th Infantry	10	-2	12.3	23.2	34.2	43	697
223rd Infantry	3	-5	13.3	24.4	35.6	39	694
224th Infantry	0	-	-	-	-	-	-
179th Infantry	24	0	14.1	22.6	31.2	43	647
180th Infantry	23	-7	9.6	20.6	31.6	41	721
279th Infantry	25	-7	10.0	20.0	30.0	40	662
(FEBRUARY)							
1st Marines	29	-5	11.6	22.2	32.9	46	762
5th Marines	29	0	13.1	22.4	31.8	42	786
7th Marines	27	-3	11.9	21.2	30.4	39	790
9th Infantry	29	-5	12.6	21.6	30.5	47	M
23rd Infantry	27	-6	12.0	22.2	32.5	43	763
38th Infantry	29	-4	13.2	22.7	32.1	43	759
7th Infantry	25	-3	15.1	24.1	33.1	49	711
15th Infantry	29	-5	11.0	22.8	34.7	44	617
65th Infantry	25	-4	16.4	25.5	36.6	46	724
17th Infantry	23	-5	14.0	29.8	35.6	47	649

RESTRICTED
Security Information

REGIMENT	Days Avail. (No.)	Lowest Temp. (°F)	Ave. Min. Temp. (°F)	Mean Temp. (°F)	Ave. Max. Temp. (°F)	Highest Temp. (°F)	Average Wind Chill (K cal/M²/hr)
			(FEBRUARY)				
31st Infantry	26	-3	12.6	22.6	32.5	46	729
32nd Infantry	25	-3	11.4	21.0	30.6	45	766
5th Infantry	9	-5	4.6	14.1	23.6	36	847
19th Infantry	0	-	-	-	-	-	-
21st Infantry	0	-	-	-	-	-	-
14th Infantry	23	-6	13.9	23.9	33.9	48	707
27th Infantry	0	-	-	-	-	-	-
35th Infantry	23	-2	15.3	24.0	32.6	46	764
160th Infantry	29	-9	11.2	21.6	32.1	48	716
223rd Infantry	26	-10	10.9	21.6	31.9	42	748
224th Infantry	14	4	18.0	26.2	34.4	42	717
179th Infantry	27	-4	12.2	22.8	33.4	47	701
180th Infantry	29	-6	12.0	23.0	33.9	45	715
279th Infantry	29	-5	12.3	22.8	33.4	48	680
			(MARCH)				
1st Marines	23	10	24.5	36.4	48.3	65	657
5th Marines	25	9	23.1	35.0	47.0	67	644
7th Marines	20	5	24.1	34.5	[illegible]	66	718
9th Infantry	31	11	25.4	35.4	45.4	60	749
23rd Infantry	31	8	24.6	35.6	46.6	63	646
38th Infantry	31	12	26.5	37.2	48.0	61	563
7th Infantry	30	20	29.9	38.0	46.0	63	567
15th Infantry	30	12	26.8	38.7	50.6	68	499
65th Infantry	31	14	27.0	36.7	46.4	60	572
17th Infantry	31	11	25.4	40.4	55.4	68	534
31st Infantry	29	13	27.7	38.0	48.2	63	584
32nd Infantry	31	13	26.3	37.4	48.5	63	578
5th Infantry	0	-	-	-	-	-	-
19th Infantry	0	-	-	-	-	-	-
21st Infantry	0	-	-	-	-	-	-
14th Infantry	30	9	24.4	34.2	43.9	59	594
27th Infantry	10	25	31.2	41.5	50.9	61	583
35th Infantry	28	8	20.3	27.3	34.3	45	904
160th Infantry	28	12	26.6	35.9	45.2	57	589
223rd Infantry	21	2	20.6	32.1	43.6	56	656
224th Infantry	29	8	25.4	35.3	45.1	55	630
179th Infantry	30	8	24.6	30.0	35.4	60	610
180th Infantry	29	9	25.4	36.1	46.8	64	623
279th Infantry	30	6	25.6	36.8	48.0	68	600

RESTRICTED
Security Information

APPENDIX IV

MONTHLY DATA FOR MAPPING TEMPERATURE DISTRIBUTION IN COMBAT ZONE

STATIONS

Station No.	Location*	Elevation (Meters)
1	CS 313983	80
2	CT 340139	80
3	CT 237160	40
4	CT 269239	80
5	CT 318282	120
6	CT 300296	185
7	CT 323307	120
8	CT 508344	220
9	CT 583344	220
10	CT 630365	200
11	CT 666395	604
12	CT 780451	260
13	CT 839456	235
14	CT 888428	240
15	CT 855166	100
16	DT 123359	350
17	DT 161329	386
18	DT 201386	1181
19	DT 250370	400
20	DT 307413	480
21	DT 313405	460
22	DT 301206	340
23	CS 725927	100

AWS Stations

Uijongbu	CS 2878	40
Chunchon	CS 8892	85
Kwandae-Ri	DT 2106	170
Seoul	CS 2158	30
Kangnung	DS 9078	20

* 1000 Meter Universal Transverse Mercator Grid.

MONTHLY DATA USED IN MAPPING DISTRIBUTION
OF TEMPERATURE IN COMBAT ZONE*

DECEMBER

Station No.	X Min.	Ave. Min.	Mean	Ave. Max.	X. Max.
1	-	-	-	-	-
2	-	-	-	-	-
3	2	22.3	30.8	39.2	49
4	-	-	-	-	-
5	-	-	-	-	-
6	-	-	-	-	-
7	-	-	-	-	-
8	-	-	-	-	-
9	-7	18.7	28.8	38.8	48
10	-	-	-	-	-
11	-	-	-	-	-
12	-16	15.5	26.0	36.5	47
13	-8	18.3	27.6	37.1	49
14	-8	19.5	27.9	36.9	53
15	-	-	-	-	-
16	-	-	-	-	-
17	0	20.0	28.3	37.1	51
18	-	-	-	-	-
19	-16	18.6	26.3	33.4	49
20	-14	20.4	28.4	36.6	52
21	-11	19.4	28.2	37.1	54
22	-3	22.9	30.6	38.4	53
23	-	-	-	-	-
AWS Stations					
Uijongbu	5	23.9	32.5	41.1	49
Chunchon	5	23.5	33.1	42.8	56
Kwandae-Ri	3	23.3	32.4	41.6	55
Seoul	12	26	34.5	43	55
Kangnung	20	32	40.5	49	64

*Data used only when location was occupied on at least 85% of the days of the month.

MONTHLY DATA USED IN MAPPING DISTRIBUTION
OF TEMPERATURE IN COMBAT ZONE*

JANUARY

Station No.	X. Min	Ave. Min.	Mean	Ave. Max.	X Max.
1	-	-	-	-	-
2	-	-	-	-	-
3	4	14.5	23.6	32.5	41
4	-8	16.8	22.2	28.0	40
5	-	-	-	-	-
6	0	14.1	22.8	31.2	43
7	-7	8.7	19.0	29.3	39
8	-6	13.4	22.4	31.4	40
9	-5	7.7	19.4	31.2	43
10	-10	5.7	18.8	31.9	42
11	-2	10.9	19.5	28.6	40
12	-10	7.9	19.0	30.2	42
13	-3	10.0	19.8	29.1	37
14	-5	8.9	20.5	32.1	40
15	-1	12.1	22.8	33.0	41
16	-2	12.5	21.7	30.9	44
17	0	12.9	22.4	29.9	38
18	-	-	-	-	-
19	-	-	-	-	-
20	-4	9.4	20.0	30.6	46
21	-7	9.2	20.2	31.3	42
22	-	-	-	-	-
23	-	-	-	-	-

AWS Stations

Uijongbu	1	17.0	25.3	33.6	43
Chunchon	0	15.6	25.2	34.8	43
Kwandae Ri	3	15.9	25.1	34.4	44
Seoul	5	18	26	34	44
Kangnung	10	26	32.5	39	50

*Data used only when location was occupied on at least 85% of the days of the month. (Exceptions noted on January map)

MONTHLY DATA USED IN MAPPING DISTRIBUTION
OF TEMPERATURE IN COMBAT ZONE*

FEBRUARY

Station No.	X Min.	Ave. Min.	Mean	Ave. Max.	X Max.
1	-3	14.9	23.9	32.7	49
2	-	-	-	-	-
3	-5	11.0	23.3	34.7	46
4	-	-	-	-	-
5	-6	12.0	22.8	33.9	45
6	-	-	-	-	-
7	-5	12.0	22.9	33.8	48
8	-4	13.2	22.8	32.1	43
9	-6	12.0	22.3	32.5	43
10	-	-	-	-	-
11	-5	12.6	21.6	30.5	47
12	-10	10.9	21.4	31.9	42
13	-5	12.8	21.5	30.2	42
14	-9	11.2	21.6	32.1	48
15	-2	15.4	25.4	35.4	46
16	-2	15.4	24.6	33.9	47
17	-	-	-	-	-
18	-	-	-	-	-
19	-	-	-	-	-
20	-2	11.9	21.1	30.4	39
21	-5	10.8	21.4	31.9	42
22	-3	14.3	23.6	32.9	45
23	-	-	-	-	-
AWS STATIONS					
Uijongbu	0	15	24.5	34	47
Chunchon	0	16	26.0	36	46
Kwandae Ri	0	16.1	24.8	33.6	44
Seoul	3	17	25.5	34	45
Kangnung	12	23	29.5	36	46

*Data used only when location was occupied on at least 85% of the days of the month.

MONTHLY DATA USED IN MAPPING DISTRIBUTION
OF TEMPERATURE IN COMBAT ZONE*

MARCH

Station No.	X Min.	Ave. Min.	Mean	Ave. Max.	X Max
1	14	27.0	38.1	46.4	58
2	9	24.8	35.9	47.0	68
3	12	26.8	39.2	50.6	68
4	-	-	-	-	-
5	9	24.7	35.8	47.0	68
6	-	-	-	-	-
7	8	24.6	35.3	46.0	60
8	12	26.5	37.1	48.0	61
9	8	24.6	35.5	46.6	63
10	-	-	-	-	-
11	8	25.4	35.7	45.4	60
12	-	-	-	-	-
13	8	25.4	35.2	45.1	55
14	-	-	-	-	-
15	11	25.4	40.4	55.4	68
16	9	24.4	34.1	43.9	59
17	-	-	-	-	-
18	8	20.3	27.3	34.3	38
19	-	-	-	-	-
20	-	-	-	-	-
21	-	-	-	-	-
22	-	-	-	-	-
23	13	26.3	37.8	48.5	63
AWS Stations					
Uijongbu	14	27.7	38.6	49.6	63
Chunchon	14	29	39.5	50	65
Kwandae-Ri	12	29.1	37.6	46.1	60
Seoul	18	30	38.5	47	65
Kangnung	17	33	39.5	46	65

* Data used only when location was occupied on at least 85% of the days of the month.

ARMY MEDICAL RESEARCH LABORATORY

FORT KNOX, KENTUCKY

REPORT NO. 113
1 April 1953

COLD INJURY - KOREA 1951-52*

Section II

AN EVALUATION OF THE SUPPLY, UTILIZATION AND ADEQUACIES OF WINTER CLOTHING FOR THE UNITED STATES ARMY IN KOREA, 1951-52

*Subtask under Environmental Physiology, AMRL Project No. 6-64-12-028, Subtask (8K), Cold Injury Studies.

MEDICAL RESEARCH AND DEVELOPMENT BOARD
OFFICE OF THE SURGEON GENERAL
DEPARTMENT OF THE ARMY

SECTION II

AN EVALUATION OF THE SUPPLY, UTILIZATION AND
ADEQUACIES OF WINTER CLOTHING FOR THE
UNITED STATES ARMY IN KOREA, 1951-52

by

Donald G. Rice
Capt., QMC, AUS

RESTRICTED
Security Information

TABLE OF CONTENTS

RESTRICTED
Security Information

RESTRICTED
Security Information

AN EVALUATION OF THE SUPPLY, UTILIZATION AND ADEQUACIES OF WINTER CLOTHING FOR THE UNITED STATES ARMY IN KOREA, 1951-52

I. INTRODUCTION

A basic approach to the prevention of cold injuries is through the issue of adequate cold weather clothing and equipment, indoctrination of troops in their proper uses and institution of energetic command action at all levels to insure the application of these necessary prophylactic measures.

Cold injuries frequently occur when inadequate clothing fails to provide sufficient body insulation. All clothing, including bootgear, must be considered, since heat losses from any part of the body affect the total organism. Inadequate handwear, footwear or body clothing may permit a lowering of body temperatures in extremely cold environments. In addition adequate protection from wetness must be provided. Wet clothing also facilitates a loss of body heat. Further care must be exercised to insure that the clothing is properly fitted to the individual to avoid any interferen with the normal circulation of blood resulting from constrictive combinations. Tight clothing, especially bootgear, should never be worn under wet-cold or dry-cold conditions such as are prevalent in Korea. The term "wet-cold" refers to mean monthly temperatures ranging from +14° to 68° F. while the term "dry-cold" refers to mean monthly temperatures below +14° F.

In general the uniform worn by United States troops in Korea during the winter of 1951-52 operating in the forward areas consisted of the following items:

RESTRICTED
Security Information

Headgear

Cap, field, pile or Cap, field, cotton

Hood, jacket, field, M-1943

Upper Body Clothing

Undershirt, wool, 50% cotton, 50% wool, or Undershirt, winter, 1950

Shirt, flannel, olive drab, stand-up collar

Sweater, high-neck, 100% wool

Jacket, field, pile, olive drab

Jacket, field, M-1943 (this jacket is water-repellent and wind-resistant)

Lower Body Clothing

Drawers, wool, 50% cotton, 50% wool, or Drawers, winter, M-1950

Trousers, field, wool serge, olive drab No. 33, 18 oz.

Trousers, field, cotton OD, or Trousers, field, cotton, M-51, (both type trousers are water-repellent and wind-resistant)

Handwear

Mittens, shell, trigger finger

Mittens, inserts, trigger finger

Gloves, shell, leather

Gloves, inserts, wool

Bootgear

Boots, combat, leather, russet or two buckle type

Shoepacs, M-1944, worn with 2 pr. socks, wool, ski, and 1 pr. insoles, felt

Boots, combat, rubber, insulated, worn with 1 pr. wool cush-

ion sole socks

Additional Items

Parka, shell, cotton, M-1948 (water-repellent and wind-resistant)

Parka, liner, pile, M-1948

Overcoat, or Parka-type w/pile liner

Wool scarf

In general the uniform worn by United States troops operating in the rear areas in Korea during the winter of 1951-52 consisted of the following items:

Headgear

Cap, filed, cotton

Hood, jacket, field, M-1943

Upper Body Clothing

Undershirt, wool, 50% cotton, 50% wool, or Undershirt, winter, M-1950

Shirt, flannel, olive drab, stand-up collar

sweater, high-neck (100% wool)

Vest, alpaca, lined

Jacket, field, M-1943 (this jacket is water-repellent and wind-resistant)

Lower Body Clothing

Drawers, wool, 50% cotton, 50% wool, or Drawers, winter, M-1950

Trousers, field, wool, serge, olive drab No. 33, 18 oz.

Trousers, field, cotton, or Trousers, field, cotton, M-51 (both type trousers are water-repellent and wind-resistant)

Handwear

Gloves, shell, leather

Gloves, inserts, wool (100% wool)

Bootgear

Boots, combat, russet or boots, combat, composition sole 2-buckle type worn with 1 pr. cushion sole socks and overshoe, arctic (this type bootgear was issued to all combat troops not issued shoepacs)

Additional Items

Overcoat, field, OD 7, with wool liner

Wool scarf

II. SUPPLY

Supplying a field Army with the proper winter clothing and equipment creates a logistical problem to insure that the riflemen, artillerymen, tank crewmen and even the clerks, cooks and truck drivers have the proper winter clothing and equipment in time to protect them against inclement weather.

To make certain that all troops operating in Korea during the winter 1951-52 were properly clothed for the environmental conditions they might encounter, a directive from the Eighth Army Quartermaster dated 9 August 1951, Subject: "Winter Clothing Allowance" was sent to all commands. This directive covered supply control, definition of troop classes, phases of issue of clothing and equipment, requisitioning procedures and the "turn-in" of summer clothing and equipment. In addition it served as the guide for all units for the requisitioning and issue of winter gear (Appendix I). The dates of issue established in this directive were not only complied with but, in many instances, cloth-

ing was in the troops possession earlier than prescribed.

The actual supply status of the required clothing items included in Phase I, II and III (see Appendix I) as of 31 October 1951 is indicated in Tables 1, 2 and 3 where the percentage of completeness values are tabulated. These data present evidence that nearly all United States divisions were completely equipped with winter clothing and accessory gear approximately four weeks prior to the onset of cold injuries. By 31 November 1951 these units had completed their initial requisitioned requirements. Assuming that these items were properly issued to the troops of the lower echelons by this date the men were prepared clothing-wise for the anticipated inclement weather. Certain units which sustained a considerable number of cold injuries during the last few days of November 1951 did have the proper winter clothing and equipment available, including the bootgear, but a failure to anticipate adverse weather conditions, coupled with serious tactical developments, kept the equipment from being issued.

The equipping of the troops with new boots designated as "Boots, combat, rubber insulated", was not included in the Phase I, II or III issues as this item did not arrive in Korea until after 31 October 1951. Table 4 shows the dates of issue of this new bootgear and the total number issued per division.

III. ADEQUACY OF THE WINTER COMBAT UNIFORM

The uniform issued to troops in Korea during the winter of 1951-52 was a "limited-standard" uniform. It now has been replaced by a new wet-cold ensemble. However, this new uniform had not been produced in sufficient quantities to make it available for the winter of 1951-52. The insulation provided by both the "limited-standard" and the "standard" wet-

TABLE 1

PERCENTAGE COMPLETENESS OF ISSUE BY DIVISIONS
FOR PHASE I CLOTHING ITEMS AS OF 31 OCTOBER 1951

Item *	1st Marine Div.	1st Cav. Div.	2nd Inf. Div.	3rd Inf. Div.	7th Inf. Div.	24th Inf. Div.	25th Inf. Div.	Total Div.
Cap, field, cotton, OD w/visor	100	76	85	99	100	93	100	94
Jacket, field, M-1943	100	100	86	100	99	100	100	98
Gloves, shell, leather, M-49	100	77	48	99	100	81	100	86
Gloves, insert, wool, M-49	100	77	91	93	100	100	85	92
Socks, wool, cushion sole	80	91	None	None	87	93	98	64
Undershirt, 50% wool, 50% ctn.	92	91	88	100	100	88	100	94
Bag, duffle or bag clo. waterproof	100	95	93	90	97	100	100	96
Blanket, wool, OD	None	100	99	100	100	84	100	83
Pads, sleeping, inflatable		To be issued approximately 15 December 1951						
Total	96	89	84	97	97	92	98	93

*Obtained from requisition data - Quartermaster EUSAK

TABLE 2

PERCENTAGE COMPLETENESS OF ISSUE BY DIVISIONS
FOR PHASE II CLOTHING ITEMS AS OF 31 OCTOBER 1951

Item *	1st Marine Div.	1st Cav. Div.	2nd Inf. Div.	3rd Inf. Div.	7th Inf. Div.	24th Inf. Div.	25th Inf. Div.	Total Div.
Drawers, OD, 50% ctn. 50% wool	100	89	97	95	100	94	98	96
Hood, Jacket, Field M-43	98	93	90	99	100	97	100	97
Shirt, flannel, OD	100	57	96	95	100	92	100	91
Suspenders, trouser	100	95	100	89	100	87	100	96
Sweater, high-neck	98	98	100	95	96	100	100	98
Trousers, field cotton, OD	95	83	98	95	100	97	89	94
Trousers, wool OD	26	88	99	99	94	73	100	83
Total	88	88	97	95	99	91	98	94

*Obtained from requisition data - Quartermaster EUSAK

TABLE 3

PERCENTAGE COMPLETENESS OF ISSUE BY DIVISIONS
FOR PHASE III CLOTHING ITEMS AS OF 31 OCTOBER 1951

Item *	1st Marine Div.	1st Cav. Div.	2nd Inf. Div.	3rd Inf. Div.	7th Inf. Div.	24th Inf. Div.	25th Inf. Div.	Total Div.
Cap, field, pile	97	92	82	99	100	80	100	93
Insole, felt, blocker type	0	16	0	96	0	96	90	50
Jacket, field, pile OD	79	96	95	100	94	86	100	93
Overcoat, field, OD-7	96	None	100	None	93	0	None	41
Parka shell and liner pile	90	92	89	81	99	99	91	92
Overshoes, arctic	99	None	100	100	100	0	None	57
Shoepacs, M-1944	69	92	99	96	93	93	91	90
Socks, wool, ski	83	85	75	99	100	94	98	91
Vest, alpaca lined	None	None	100	None	None	100	None	29
Bag, sleeping, mountain	100	97	100	87	100	82	100	95
Bag, sleeping, wool	None	0	100	0	100	100	45	49
Case, water-repellent	99	90	98	100	100	100	100	98
Muffler, wool OD	100	100	67	100	99	92	100	94
Mitten, shell, trigger-finger	100	63	50	100	83	62	100	86
Mitten insert, trigger-finger	100	90	49	99	100	94	100	90
Total	93	83	89	96	93	91	94	91

NOTE: The 45th and 40th Infantry Divisions were sent to Korea from Japan and received all Phase I, II, and III items prior to departure.

*Obtained from requisition data - Quartermaster EUSAK

TABLE 4

DATES OF COMPLETION OF ISSUE
OF THE BOOT, COMBAT, RUBBER, INSULATED*

2nd Inf. Division	Div. Total 6,000 pr.
9th Inf. Regt	21, 22 and 23 Dec. 1951
23rd Inf. Regt	25 Dec. 51 thru 5 Jan. 1952
38th Inf. Regt	2 Jan. 1952
7th Inf. Division	Div. Total 6,000 pr.
17th Inf. Regt	30 Dec. 1951
31st Inf. Regt	30 Dec. 1951
32nd Inf. Regt	28 Dec. 1951
3rd Inf. Division	Div. Total 6,000 pr.
7th Inf. Regt	11 Jan. 1952
15th Inf. Regt	12, 13 and 14 Jan. 1952
65th Inf. Regt	19, 20 and 21 Jan. 1952
25th Inf. Division	Div. Total 6,000 pr.
14th RCT	30 and 31 Jan. 1952
27th Inf. Regt	20 Feb. 1952
35th Inf. Regt. except 3rd Bn	8 Feb. 1952
35th Inf. Regt. 3rd Bn	20 Feb. 1952
40th Inf. Division	Div. Total 6,000 pr.
160th Inf. Regt	5 Feb. 1952
223rd Inf. Regt	6 Feb. 1952
224th Inf. Regt	5 Feb. 1952
45th Inf. Division	Div. Total 6,000 pr.
179th Inf. Regt	7, 8 and 9 Feb. 1952
180th Inf. Regt	29 and 30 Jan. 1952
279th Inf. Regt	1, 2 and 3 Jan. 1952

Note: 1. All above Divisions were issued 1,000 additional pairs of the boots, combat, rubber, insulated between 23 and 25 Feb. 1952, making a total of 7,000 pair per Division.

2. The 1st Marine Division had sufficient stocks on hand to issue the insulated boot to all members of the Division. A Marine indoctrination team had completed issue and training of troops in the use and principles of this new type footgear during the month of October 1951.

* Obtained from requisition and issue data - Quartermaster EUSAK

cold uniform is basically the same. The new "standard" wet-cold uniform, through the use of four top body layers, provides as much insulation as the "limited-standard" with five top body layers and permits more efficient ventilation for the prevention of overheating.

The following are selected comments regarding various items of the "limited-standard" wet-cold ensemble issued during the winter of 1951-52:

Undershirt, wool, 50% cotton, 50% wool

This undershirt was unsatisfactory because its design caused binding at the armpit. It was also difficult to put on and take off. Its snug fit prevented proper ventilation.

Shirt, flannel, OD

This shirt provided an excellent layer of insulation and was capable of easy ventilation.

Sweater, high-neck

This sweater was difficult to put on and take off because it was a slip-over type. It also did not allow proper ventilation. Many sweaters issued during the winter of 1951-52 had been renovated from the existing stock of the previous winter. Shrinkage caused by cleaning reduced the insulating value of the underlayers.

Jacket, field, pile, OD

One of the main disadvantages of this item was it could not be worn as an outer garment since the material used was neither wind-resistant nor water-repellent. It also had a tendency to creep and binding resulted.

Jacket, field, M-1943

This jacket permitted better ventilation and allowed freedom of body movement. It was easy to put on and take off. It had adequate pocket spaces and it was water-repellent and wind-resistant. This made the item very versatile. Many troops expressed a desire for a zipper closure and a draw-string at the bottom as well as at the middle of the jacket.

Drawers, wool, 50% cotton, 50% wool

These drawers were difficult to put on and take off. Their snug fit prohibited proper ventilation.

Trousers, field, wool, OD

These trousers allowed freedom of body movement. They were easy to put on and take off and provided a satisfactory inner layer of insulation. Many troops desired a zippered instead of buttoned fly.

Trousers, field, cotton

These trousers allowed freedom of body movement except when kneeling or squatting. They tended to bind at the knees and seat. They were easy to put on and take off. Many of the troops expressed the desire for additional pocket space, such as cargo pockets on the legs of the trousers, and also a zipper fly.

Hood, jacket, field, M-1943

This hood protected the neck and head from wind and rain.

Handwear (Mittens, shell, trigger-finger, w/wool inserts and Gloves, shell, leather, w/wool inserts)

Both types of handgear were worn during the winter of 1951-52. The general opinion of front-line infantrymen was that

the trigger-finger mitten with the wool insert provided greater climatic protection but did not permit as much dexterity as did the glove, shell, leather, w/wool insert. Almost universally the wool inserts were worn with the outer shell for both types of handwear. There were many situations, however, in which the trigger-finger mitten had to be removed in order to provide the necessary dexterity needed in such emergency activities as: Jamming of small arms and automatic weapons; adjustment of artillery sights; splicing of communication wire; performing first aid by medical corpsmen; etc. As a result of the removal of the handgear, losses of this item occurred. Such losses coupled with prolonged exposure resulted in frostbite. Because of the lessened dexterity when wearing mittens, certain infantrymen preferred to use the five-fingered glove which provided less protection against cold. To prevent loss of handgear in combat, a recommended solution is to attach the handgear to a neck cord similar to that used with the arctic mittens. Some troops did improvise and use this method. Possible approaches to the solution of the problem of heat conduction from the hands are: 1) modification of handgear which will permit maximum dexterity and yet provide maximum protection, e.g., use of protective anti-contact liners which will remain on the hand, giving some protection against cold injury when the outer shell is removed momentarily in emergencies; 2) use of impermeable outer shell materials to provide protection against wetting. Pending development of such materials it is suggest-

ed that men be instructed to carry xtra wool inserts.

Undershirt and Drawers, winter, M-1950

This is a very satisfactory item. The new "standard" underwear was designed to fit loosely over the body in a manner similar to pajamas; in contrast to the former standard garments which were form-fitting. The new underwear gives the soldier added insulation, increased freedom of movement and better ventilation. The drawers have a loose-fitting elastic waistband. Loops located at the waist are included for attaching suspenders. The new design also provides sufficient material so that the small amount of shrinkage which occurs with laundering will not cause the underwear to become tight and binding. The drawers are constructed to prevent binding while squatting or kneeling. These two items are in every respect far superior to the "limited-standard" Undershirt, wool, 50% cotton, 50% wool, and the Drawers, wool, 50% cotton, 50% wool.

Bootgear

Three types were worn during the winter of 1951-52: Boots, combat, russet or 2-buckle type; Shoepacs M-1944; Boots, combat, rubber insulated. Late in November of 1951 a large group of cold injuries occurred in two separate units. The frostbite casualties of these units were wearing the combat leather boots in spite of the fact that the shoepacs had been issued. Lack of appreciation of climatic changes in Korea at this time of the year by the unit commanders resulted in the occupation of a hill by troops garbed in

leather boots. This newly occupied position formerly had been held by Republic of Korea (ROK) troops. The ROK foxholes were shallow and required extensive remodeling. Shortly after occupation of this hill a combination of snow and cold, inadequate shelter and a forceful enemy attack immobilized the troops and prevented the exchange of leather boots for shoepacs which had been left in the rear battalion headquarters area. News of this regrettable experience soon spread across the entire front and commanders of all echelons became more aware of the dangers of improper clothing and cold weather. Vigorous training and control measures were promptly instituted to prevent similar occurrences.

Boots, combat, all leather. These leather boots were unsatisfactory as an item of bootgear for troops operating in the forward areas but satisfactory for troops in rear areas when worn with the arctic overshoes. They should never be worn alone on wet and water-logged surfaces. The range of actual air temperatures for recommended use is from +41° to +104° F. This item was never intended to be used as winter bootgear. This combat boot was designed to be worn over one pair of cushion sole socks. This is not considered sufficient insulation for the winter months in Korea. These leather boots have a low toe cap which can limit the movement of the toes. Leather combat boots do not have a removable insole which is needed for added insulation under the foot in wet-cold climatic conditions. In some cases men believing that an extra thick sock would

provide more insulation wore ski socks with the leather combat boot. In most instances this proved to be of little value since an extra heavy sock resulted in embarassment of circulation and probably contributed to cold injury. Except for the use of the leather boot at the onset of the Korean winter (1951-52) previously mentioned, the majority of the front-line infantrymen wore shoepacs during November, December and early January. Most of the supporting troops wore the shoepac the entire winter.

Shoepacs. The shoepac is a 12 inch high boot whose lower section to the ankle level is made of rubber and upper portion of leather. The rubber portion of the boot provides traction and is waterproof for wet and waterlogged surfaces under wet-cold conditions. The thermal insulation is provided by two pairs of heavy wool ski socks of different sizes (if size 10 sock is normally worn, one pair of size 10 and one pair of size 11 ski socks would be required) along with one pair of heavy felt insoles. The shoepac seemed to provide adequate protection under certain combat conditions when properly fitted and worn with suitable sockgear and insoles. However, a major defect was the loss of the necessary insulation provided by the layers of the sockgear when they were saturated with sweat. Subsequent immobilization usually resulted in a cold injury. A number of shoepacs were issued which did not have a steel shank

for arch support nor an adequate seal between the rubber bottom and the leather top. The carrying of extra sock-gear for changing while on combat missions to provide dry effective insulation was not always militarily expedient nor was it practiced to often in Korea. The shoepac itself was impermeable to moisture emitted from the foot in the form of sweat. The prolonged wet condition of the foot softened the skin and contributed to the disabling sequelae of maceration. The shoepac, in general, necessitates a high level of logistical support because of the number of socks and extra insoles required for protection against cold. Examples of the logistical difficulties encountered were the frequent launderings and mismanagement in sock exchange, resulting in the return of improper sized sock combinations to the individual soldier. Constriction of the feet occurred if the individual socks were too small or if the outer layer was equal in size to the inner layer. Boots, Combat rubber insulated. The issuance of the new rubber, insulated, combat boot was limited by the availability of supply. It was not until late in February 1952 that issue was complete for all United States divisions. The original 6,000 pairs per division, which were later increased to 7,000 pairs per division, were issued primarily to the front-line infantrymen, medical corpsmen and other personnel who were associated very closely with the activities of infantry units. The 1st Marine Division was the only unit which had sufficient quantities of the new type boot-

gear to equip all personnel. This boot is made of two layers of black rubber and is 11-1/4 inches high. The foot and ankle portion is insulated with a layer of 14 oz. wool fleece and the sole with a 1/2 inch felt pad. The rubber sole and heel are cleated for traction. A shelf is provided on the back of the heel for securing snowshoe and ski bindings. A steel shank is incorporated for arch support. The fleece and felt pad insulation are vulcanized between the inner and outer rubber surfaces, thereby protecting the insulation from either internal or external moisture. This provides continual dry insulation thus preventing heat loss. In this respect there is a decided advantage over the shoepac which loses its protective value as the sock layers become wet from sweat or water. The new boot is worn with only one pair of cushion soled socks. This eliminates many of the logistical problems which [illegible]ist with the shoepac. Danger of constriction in the feet is reduced. Indoctrination of troops in the principles and use of this new type bootgear was required and a special training program was instituted. There was enthusiastic and spontaneous acceptance of the new boot. The mission of training the troops in the use of the new boot was assigned to the Quartermaster Wet-Cold Indoctrination Teams. Assistance in this training and fitting program was given by special representatives from the Department of the Army, Office of the Quartermaster General and the Cold Injury Research Team. In all units the principle of the insulated boot

was explained in detail so that the individual soldiers fitted with the new boot would know its capabilities and limitations. Data revealed a definite reduction in the incidence of lower extremity cold injuries immediately following the issuance of the new boot (See Epidemiology Section of the combined report). Relatively few deficiencies were encountered with the insulated boot, such as ripping of the outer rubber layer with resultant wetting of the fleece insulation. This might be overcome in part by the conversion of the insulation from fleece to a plastic substance or other material. The retention of sweat by the relative absence of absorbing materials led to maceration followed by partial denudation of the sole of the foot and aggravation of existing epidermophytosis. However, strict attention to the basic principles of foot hygiene will suffice to overcome these difficulties. It was felt that some mechanical or other form of ventilation was required in order to remove the vapor (moisture) without reducing the insulating quality of the boot. The boots, produced by various manufacturers, varied in size, width and stiffness. In some boots the hook eyelets pulled out. In others the top of the boot, at the bellows junction, chafed the calf, especially in those individuals with heavy leg structure. Many men expressed difficulty in putting on and taking off the boot when socks were wet. The majority of infantrymen interviewed regarding this new type bootgear agreed that it was by far the best for winter

operations from the standpoint of both warmth and over-all comfort. One important finding was that this boot did not require any "breaking in" as do most types of Army bootgear. Another interesting note was that four men while wearing the new insulated boot stepped on anti-personnel mines and incurred only minor sprains, whereas serious foot injuries are to be expected with the combat boots or shoe-pacs.

Table 5 shows the various types of combat bootgear issued in Korea during the winter of 1951-52 with respect to the required sockgear for each type, their function, the surface conditions under which each was used and the range of ambient temperatures for satisfactory use.

IV. WET-COLD TRAINING

Preparation for the cold weather training program for the winter 1951-52 began in July 1951. At that time there were four teams in Korea who had participated in the program during the winter 1950-51. In July the teams formalized the winter training program by initiating: 1) surveys at unit levels to determine clothing requirements; 2) review of clothing records with regard to current sizes needed and 3) preparations of requisitions for the necessary winter clothing equipment. This activity continued throughout July and August 1951.

In the winter of 1951-52 however, a decision was made that the four Quartermaster Corps teams would be utilized for the training of unit instructors who would, in turn, instruct all personnel of their respective organizations. The training responsibility was made part of the command responsibility. A team consisted of one officer and one NCO

TABLE 5

TYPES OF COMBAT FOOTGEAR USED IN KOREA BY AMERICAN TROOPS DURING THE WINTER OF 1951-52 WITH RESPECT TO THEIR REQUIRED SOCKGEAR, OPTIMUM FUNCTION AND AMBIENT TEMPERATURE RANGE*

Item	Sockgear Required	Function	Ground Surface Requirement	Range of Ambient Temperature For Use
Boots, service, combat, russet	Socks, wool, cushion sole 1 pr.	General Use	Generally dry surfaces under temperate conditions	+41° to +104° F.
Boots, service, combat, composition sole (2-buckle type)	Socks, wool, cushion sole 1 pr.	General Use	Generally dry surfaces under temperate conditions	+41° to +104° F.
Shoepac, M-1944	Socks, wool, ski 2 pr. Insoles, felt 1 pr.	Provides traction waterproof ski & snowshoes	Wet and waterlogged surfaces under wet-cold cond.	-4° to +59° F.
Boots, combat, rubber, insulated	Socks, wool, cushion sole 1 pr.	Provides traction waterproof ski & snowshoes	Wet and waterlogged surfaces under wet-cold cond.	-4° to +59° F.

* Obtained for footgear charts Clothing Almanac No. 10 China and Korea OQMG

instructor assigned to a corps. Later in the winter an additional team was assigned to each corps making a total of six teams. When training sessions for each division and corps had been completed, additional instruction periods were held for training unit instructors for corps artillery, engineer, signal and miscellaneous units. In addition to instructor teams from the units in the Pusan area and the 2nd Logistical Command, a team was provided which was responsible for training new units arriving in Korea. The United Nations Training Center also had a team which was responsible for the training of new United Nations units as they arrived in Korea.

The training sessions for unit instructors were scheduled to cover a two-day period and consisted principally in a discussion of the various types, signs, causes and possible effects of cold injuries. Training aids, including clothing demonstration sets, were also distributed to each unit instructor. Included in these sessions was a practical demonstration in the proper wearing of various clothing items. Opportunity was provided for consideration of individual problems by quartermaster team members.

Training of all division, corps, artillery, signal and engineer teams was completed by 10 October 1951. Training of area commands except Pusan had been scheduled and completed by 1 November 1951. Fifth Air Force training officers were instructed on 24 October and 2nd Logistical Command unit instructors in the Pusan area between 12 and 15 November.

Spot announcements from Armed Forces Radio Stations were made daily throughout the winter reminding listeners of measures to be taken in cold injury prevention.

Many times difficulties were encountered by changes of command. New officers, particularly in company grades, through lack of knowledge of preventive principles of cold injury and the proper use of cold weather clothing, wore wrong types of clothing and, sometimes, issued direct orders which often undermined all previous instructions given by the Quartermaster Wet-Cold Indoctrination Teams. Many new officers who entered the combat zone missed the cold weather training given at United States Ports of Embarkation or at Replacement Centers in Japan. In view of the above, a definite requirement is needed, whereby all officers ordered to a wet-cold combat area receive training in the proper use of clothing and equipment needed for cold weather combat.

V. CONCLUSIONS

The supply of winter clothing was adequate and effectively handled at all echelons of supply. With few exceptions, the necessary cold weather clothing was available in sufficient time to provide United States troops with the proper items for the utmost protection against environment. The wet-cold uniform issued to United States troops in Korea for the winter 1951-52, in most cases, provided adequate insulation and protection against the most severe environmental conditions experienced. The shoepac will provide greater protection to troops in the rear or non-combat area than the leather combat boot. The insulated rubber boot was the most suitable bootgear available for wet-cold conditions. Strict foot hygiene principles should be observed at all times with all types of bootgear. The new insulated boot was probably directly responsible for a reduction in the total amount of cold injury sustained by United States troops in Korea during the winter 1951-52. The trigger finger mittens provided the most protection

against cold injury. The trigger finger mitten, however, does not allow satisfactory dexterity. The wet-cold training program, winter 1951-52, was superior to that of the previous year, 1950-51.

VI. RECOMMENDATIONS

1. The insulated rubber combat boot should be considered the desired item of wet-cold bootgear for all troops engaged in combat. The capabilities of the insulated boot could be improved by replacing the fleece insulation with a type which does not wet as easily.

2. The shoepac, M-44, should be issued to only rear and noncombatant personnel.

3. The shoepacs made prior to the M-44 model should be declared obsolete and taken out of supply channels.

4. Cold injury training should be made a part of the soldier's basic training course. Similar training should be given at all officer's basic and advanced courses. Whenever a new item of clothing or equipment is to be supplied all troops should be properly trained in its application.

5. A record of cold weather indoctrination should be entered on the soldier's WDAGO form 20 and the officer's WDAGO form 66.

APPENDIX I

WINTER CLOTHING ALLOWANCE, ISSUE AND TURN-IN,

KOREA, 1951-52

RESTRICTED
Security Information

HEADQUARTERS
EIGHTH UNITED STATES ARMY KOREA (EUSAK)
Office of the Commanding General
APO 301

AG 400 KQM   9 August 1951

SUBJECT: Winter Clothing Allowance

TO: See Distribution

1. General. Maximum allowances of selected winter clothing and equipment for issue in this command to military personnel shall be as prescribed herein.

2. Supply Control.

a. The supply of all winter clothing and equipment will be sufficient only with the strict application of supply control measures. Items not required will not be requisitioned. Mountain sleeping bags will be the most critical of all winter items. Upon the departure of an individual from the forward area, this item will be turned in to unit supply officer for reissue to incoming replacements.

b. Those troops billeted and performing duty in the cities of Pusan, Masan, Taegu, Inchon, Ascom City and Seoul are not authorized pile caps, and mountain sleeping bags.

3. Definitions of Troop Classes.

a. Class A: Those units which habitually operate in the forward active combat zone and which are in physical contact with the enemy. Living conditions usually require extended use of foxholes.

b. Class B: Those units which habitually operate in the forward active combat zone and are occasionally in physical contact with the enemy. Living conditions usually permit somewhat better protection from the elements than Class A units.

c. Class C: Those units which habitually operate in the Army or Corps service area of the combat zone, where housing is sometimes furnished and protection from the elements can usually be improvised to a better degree than in the preceding classes.

RESTRICTED
Security Information

d. Class D: Those units which are normally based at an airfield where base facilities and conditions permit use of housing, tentage and/or semi-permanent buildings. Twenty-four hour protection from the elements is usually at a maximu. Normal living and working conditions at the installation will usually provide protection from the elements.

e. Class E: Those units which habitually operate from permanent or semi-permanent installations in the rear areas of Korea wherein housing is usually provided.

4. Phases of Issue of Clothing and Equipment. Winter clothing and equipment will be issued in the three phases as follows:

a. Phase I. The following items of winter clothing will be available, on basis indicated, by 1 September 1951:

Clothing

Item	Unit	Allowance
Cap, field, cotton, OD w/visor	ea	1 per individual
Jacket, field, M-1943	ea	1 per individual
Gloves, shell, leather, M-1949	pr	1 per individual
Gloves, insert, wool, M-1949	pr	2 per individual
Socks, wool, cushion sole	pr	5 per individual
Undershirt, 50% wool, 50% ctn	ea	3 per individual
Bag, duffle or bag clothing waterproof	ea	1 per individual
*Blanket, wool OD	ea	2 per individual
Pads, sleeping, inflatable	ea	1 per individual

b. Phase II. The following items of winter clothing and equipment will be available for issue on basis indicated by 1 October 1951.

Clothing	Unit	Allowance
Drawers, OD, 50% ctn, 50% wool	ea	3 per individual
Hood, jacket, field M-1943	ea	1 per individual
Shirt, flannel, OD	ea	2 per individual
Suspenders, trouser	ea	1 per individual
Sweater, high-neck	ea	1 per individual
Trouser, field, cotton, OD	pr	2 per individual
Trousers, wool OD	pr	2 per individual

c. Phase III. The following items of winter clothing and equipment will be available for issue on basis indicated by 1 November 1951:

Clothing	Unit	Allowance
Cap, field	ea	1 per individual Class A, B, & C

RESTRICTED
Security Information

9 August 1951

Clothing	Unit	Allowance
Insoles, Felt, Blocker type	pr	2 per individual issued shoepacs, M-1944
Jacket, Field, pile, OD	ea	1 per individual Class A, B, & C troops
Muffler, wool, OD	ea	1 per individual
Overcoat, field, OD-7	ea	1 per individual Class D & E troops
Overcoat, parka type, or parka liner, pile and parka-shell, ctn	ea	1 per individual Class A, B, & C troops (Overcoat, OD-7 may be issued as a substitute item)
Overshoes, arctic	pr	1 per individual not issued shoepacs
Shoepacs, M-1944	pr	1 per individual Class A, B, & C troops
Socks, wool, ski	pr	6 per individual Class A, B, & C troops
Vests, alpaca, lined	ea	1 per individual Class D & E Troops
Equipment		
*Bag, sleeping, mountain	ea	1 per individual Class A, B, & C troops except KATUSA
*Bag, sleeping, wool	ea	1 per individual Class D & E troops and KATUSA
*Blanket, wool, OD	ea	1 per individual issued bag, sleeping, wool
Case, water-repellent	ea	1 per bag, sleeping, mountain or wool
Mittens, shell, trigger-finger	pr	1 per individual Class A, B, & C troops
Mittens, insert, trigger-finger	pr	2 per individual Class A, B, & C troops

*Maximum bedding allowances are as follows:

One (1) bag, sleeping, mountain and two (2) blankets, wool, OD or one (1) bag, sleeping, wool, OD and three (3) blankets, wool, OD.

RESTRICTED
Security Information

AG 400 KQM RESTRICTED Security Information 9 August 1951
SUBJECT: Winter Clothing Allowances

5. Requisitioning Procedure:

a. Divisions: Divisions will submit requisitions for all winter clothing for organic units and units attached by competent orders to the 55th Quartermaster Base Depot, pursuant to schedule in par d. below.

b. Non-Divisional Units: Requisitions for all winter clothing will be submitted to nearest Class II & IV Supply Point, pursuant to schedule in par d. below.

c. UN Troops: Separate requisitions will be submitted for each United Nations Unit. EUSAK Cir 111 applies.

d. Separate requisitions for phases indicated in par 4 will be submitted as follows:

Phase	Date
I	Not later than 1 Sept 51.
II	Not later than 15 Sept 51.
III	Not later than 1 Oct 51.

e. Separate cover sheets, marked SECRET, will be attached to each requisition, containing the following information:

(1) Designation and strength of requisitioning unit.

(2) Designation and strength of units attached by competent orders for which requisitioning unit is responsible for Class II & IV logistical support.

f. One (1) copy of the SECRET cover sheet will be forwarded this headquarters, Attention QM.

g. Requisitions will be properly accomplished indicating quantity authorized, on hand and due in, and quantity required.

h. Items immediately available will be marked D/O by the supplying agency; therefore, it will not be necessary for units to submit subsequent requisitions for items so marked.

i. The issuing agency may make authorized substitutions for sizes or items. Such substitutions will be authorized on the action copy of the requisition.

RESTRICTED
Security Information

RESTRICTED
Security Information

AG 400 KQM
SUBJECT: Winter Clothing Allowances

9 August 1951

6. Turn in of summer items of clothing will be made through salvage channels when no longer required. A concentrated effort will be made to recover the maximum quantities of summer clothing items.

BY COMMAND OF GENERAL VAN FLEET:

DISTRIBUTION
"A"
Plus 50 copies 5th Air Force
Plus 100 copies QM Section

/s/ C. O. Overstreet
C. O. OVERSTREET
Captain, AGC
Asst AG

RESTRICTED
Security Information

HEADQUARTERS
EIGHTH UNITED STATES ARMY KOREA (EUSAK)
Office of the Commanding General
APO 301

AG 422 KQM-O 11 March 1952

SUBJECT: Turn-in of Quartermaster Winter Clothing and Equipment

TO: See Distribution

1. A positive and continuing program will be instituted for the turn-in of clothing and quartermaster equipment issued for use during the winter. As the need for seasonal items diminishes, a substantial reduction in the supply load carried by individuals and units can be accomplished by collecting and turning in these items. A carefully planned and executed program will prevent the loss or misuse of articles and will permit sufficient time for their processing and renovation.

2. These programs will provide for a phased turn-in of winter items. Those elements of a command not subject to prolonged exposure to adverse weather conditions may begin this program upon receipt of these instructions. However, all commands will accomplish this program in accordance with the schedule attached as an inclosure hereto. Careful compliance with these procedures will enhance the Army-wide supply economy program and will assist in distributing the work load on receiving and reclamation agencies.

3. Major commands will collect all items to be turned in under this program from assigned and attached units and deliver them to supporting army quartermaster salvage collecting points. Modifications to this procedure, in order to utilize direct rail shipments from division supply points, may be made by arrangement with the Quartermaster Section, this headquarters. Separate units will deliver these to supporting army quartermaster salvage collecting points.

4. To provide for more efficient handling, facilitate documentation, and prevent unnecessary loss or damage, items will be prepared for turn-in within the capabilities of the command, as outlined below.

a. All items will be searched. Ammunition and extraneous objects will be removed.

b. Items of clothing and equipment that lend themselves to bundling, will be tied into packages containing either 5 or 10 like items to permit easy handling.

c. Footwear to include boots, arctic felt; overshoes, arctic; shoepacs; and boots, combat, rubber, insulated; will be cleaned, dried, paired, and securely fastened together. Used felt insoles, issued with

AG 422 KQM-O 11 March 1952
SUBJECT: Turn-in of Quartermaster Winter Clothing and Equipment

the shoepac, will be burned by units. Unused felt insoles will be turned in.

d. The heater, tent, gasoline, 250,000 BTU (Herman-Nelson) will be cleaned and drained of fuel. The heater, with all its component parts, will be crated by using units. Crating material will be available at army quartermaster class II and IV supply points.

e. Prior to turn-in, tent stoves, burners, and stove pipe, will be serviced as follows:

(1) Stoves will be cleaned, nested, and banded.

(2) Burners will be dismantled and thoroughly clenaed.

(3) Hoses and tools will be packed inside the flame pot.

(4) Carburetors will be drained of fuel and placed in wooden sundries supplement pack (100-1 PX) boxes.

(5) Stove pipe will be cleaned and bundled. It will be protected with wood slatting and banded.

f. Stove, Yukon, will be cleaned, its component parts placed within the stove, and then banded or tied. Stove pipe issued with the stove, Yukon, will be cleaned and bundled as indicated in paragraph 4 e (5) above.

g. Tentage that is to be turned in will be dried, folded, tied, and tagged to indicate the proper nomenclature of the tent. Tent poles and pins will be packed separately.

h. All other individual or organizational equipment to be turned in will be cleaned and crated or packed in suitable containers.

5. Provisions will be made to protect items against rain and ground moisture so they will not become unserviceable or damaged as a result of mildew.

6. Items turned in will be accompanied by turn-in slip (WD AGO Form 447) prepared in quadruplicate. After the count has been verified by army salvage personnel accepting delivery, a receipted copy of the turn-in slip will be returned to the unit. Quartermaster salvage collecting points will maintain records, by units, of all items turned in.

7. With the exception of underwear and socks, which will be retained, turn-in of KSC winter clothing will be effected in accordance with procedures outlined above. Bundles will be plainly tagged "KSC Clothing". Other KSC items to be turned in will include one blanket from each individual, and all stoves, tent, with component parts.

RESTRICTED
Security Information

AG 422 KQM-O 11 March 1952
SUBJECT: Turn-in of Quartermaster Winter Clothing and Equipment

8. Items of United States property which have been issued to other United Nations forces will be accepted and receipted for in accordance with provisions of paragraph 9b and c, Circular 157, this headquarters, dated 2 October 1951.

9. All commanders will take aggressive action to insure compliance with this directive.

BY COMMAND OF GENERAL VAN FLEET:

JOHN F. KOLO
Major, AGC
Asst AG

1 Incl
Turn-in Schedule for
Winter Clo and Equip

DISTRIBUTION
"A"

RESTRICTED
Security Information

RESTRICTED
Security Information

TURN-IN SCHEDULE FOR
WINTER CLOTHING AND EQUIPMENT

Turn-in periods for units operating north of the Taejon-Andong line:

Phase I 15-30 Mar	Phase II 15-30 Apr	Phase III 1-15 May	Phase IV 15-30 May
Boots, arctic, felt	Boots, combat, rubber insulated	Gloves, shell w/insert	Burner, stove, tent
Mittens, overwhite	Cap, field, pile	Jacket, field, pile	Drawers, wool
Parkas, overwhite	Hood, jacket, fld, M-43	Mittens, shell, T/F w/insert	*Heater, tent gasoline, 250,000 BTU (Herman-Nelson)
Trousers, overwhite	Muffler, wool	Vest, alpaca	Overshoes, arctic
	Overcoat, OD No. 7		Shirt, flannel
	Parkas, all types		Stove, tent
	Shoepacs		Stove, Yukon
	Socks, wool, ski		Sweater, high-neck
			Trousers, field, wl
			Undershirt, wool

Phase V
1-15 June

** Bag, sleeping, mountain, w/case, water-repellent.
Blankets in excess of two per individual or 1 bag, sleeping, wool and one blanket.

Turn-in periods for units operating south of the Taejon-Andong line:

Phase I 15-30 Mar	Phase II 1-15 Apr	Phase III 1-15 May	Phase IV 15-30 May
Parkas, all types	Cap, field, pile	Burner, stove tent	**Bag, sleeping, mtn w/case, water repellent
	Hood, jacket, field, M-43	Drawers, wool	Blankets in excess of 2 per individual or 1 bag, sleeping, wool and 1 blanket
	Jacket, field, pile	Gloves, shell leather, w/insert	Overshoe, arctic
	Mittens, shell, T/F w/insert	***Heater, tent, gasoline, 250,000 BTU (Herman-Nelson)	
	Muffler, wool	Shirt, flannel	
	Overcoat, OD No. 7	Stove, Yukon	
	Shoepacs	Stove, tent	
	Socks, wool, ski	Sweater, high-neck	
	Vest, alpaca	Trousers, field, wool	
		Undershirt, wool	

* For hospitals, turn-in period is extended to 1-15 June.
** If option of one (1) Bag, sleeping, wool and one (1) blanket is exercised, case, water repellent will be retained for use.
*** For hospitals, turn-in period is extended to 15-30 May.

RESTRICTED
Security Information

Inclosure No. 1

SECTION III

PRE-EXPOSURE SURVEY OF COMBAT TROOPS

KOREA, 1951-52

by

Ellsworth B. Cook
Lt. Cmdr., MSC, USN

ARMY MEDICAL RESEARCH LABORATORY

FORT KNOX, KENTUCKY

REPORT NO. 113
1 April 1953

COLD INJURY - KOREA 1951-52*

Section III
PRE-EXPOSURE SURVEY OF COMBAT TROOPS, KOREA, 1951-52

*Subtask under Environmental Physiology, AMRL Project No. 6-64-12-023, Subtask (8K), Cold Injury Studies.

MEDICAL RESEARCH AND DEVELOPMENT BOARD
OFFICE OF THE SURGEON GENERAL
DEPARTMENT OF THE ARMY

TABLE OF CONTENTS

PRE-EXPOSURE SURVEY OF COMBAT TROOPS

KOREA 1951-52

I. INTRODUCTION

The primary objective of the pre-exposure study was to determine through the media of a semi-controlled interview and brief physical examination whether any factors could be delineated that would indicate an increased susceptibility to cold among individuals serving as front-line troops in the Korean theater. It was anticipated that a large segment of United States infantry personnel could be interviewed prior to cold exposure and that a sizable number of the eventual frostbite casualties would be represented in the pre-exposure population. Had this been realized, comparative studies between the frostbite and non-frostbite groups could have been accomplished. It soon became evident, however, that the estimate of the total number of interviews possible was highly optimistic in view of the fact that a single interviewer had to cover the entire theater. This, combined with the fact that the incidence of cold injury for the 1951-52 winter was quite low, prevented the realization of the principal objective of this phase of the cold injury study. Only two of the 1,628 infantrymen interviewed eventually became frostbite casualties, hence no internal analysis of the pre-exposure data was attempted.

The interview utilized a questionnaire designed to explore such aspects as race, climatological background,

education, cold weather training, pertinent medical history, tobacco and alcohol usage, as well as certain biological factors represented by pulse rate, oral temperature, body type, to mention but a few. The questionnaire will be discussed in detail in a later section.

A secondary objective involved the collection of blood samples for subsequent cold hemagglutinin analysis in the laboratory of the Cold Injury Research Center in Japan. This phase of the study attained a more satisfactory population; approximately 3,000 samples (521 from pre-exposure population) were forwarded to the laboratory for analysis. The results are reported in the section of the combined cold injury report concerned with the cold hemagglutinins (Section XIII).

The many difficulties which were encountered in attempting to collect such data in the very heart of a war will be described at some length, together with recommendations for improving the efficiency of collection in the future.

II. METHOD

To facilitate the discussion of the methods employed, this section has been subdivided into three main areas, the site of interview, the questionnaire and the collection of blood samples.

A. The Interview Site

1. Forward Areas

a. Division in Reserve

Periodically, as the military tactical

situation permitted, a whole division would be relieved from active combat duty and moved back 30-40 miles from the immediate front-line zone for the purpose of rest and reorganization. It was believed that suitable arrangements for interviewing could be established in such units. The plan of operation included sampling men from each battalion of the three regiments in order to achieve a satisfactory cross section of the division. Although the division in reserve had no immediate combat responsibilities, other factors were introduced which tended to slow down the interrogations. For example, an intensive field training program was instituted by the regiments during this period; this placed a limitation on the availability of men for interview. Night problems were often involved so that the men were required to sleep during the day. The interview site was usually the battalion aid station. In the reserve area this station normally consisted of a squad tent doubling as sleeping quarters for the corpsmen. Consequently, the tent was very crowded and interviewing could not be started until after the morning sick call. In addition there were many subsequent interruptions for emergency

treatment. The tents were often cold and drafty with very poor lighting which hampered certain aspects of the physical examination, such as foot examination, color changes in the great toe, etc.

Even with advance scheduling of men for interview, long delays would frequently be experienced because of misunderstandings or sudden changes in the training schedule. The interviewer usually lived with the medical battalion where billeting space was not at such a premium. A disadvantage resulted, however, from the relatively long daily drives required to reach the various battalions. Restrictions imposed by the division to eliminate unnecessary travel in darkness tended further to shorten the working day.

b. Regiment in Reserve

Certain divisions, when "in the line", employed a rotational system in which one regiment was kept back in a blocking position and was considered to be in a "reserve status". The same problems discussed above were present to a greater degree here, especially those concerned with tr vel between units and availability of men for interview. Additional complications arose from the necessary reduction of working facilities imposed by the combat area.

c. Battalion in Reserve

It was common practice for regiments when "in the line" to keep one battalion back in a blocking position and to follow a rotational system as mentioned above for the regiments. On occasion this so-called "reserve" battalion was used for interviews with the same problems described above.

2. Rear Areas

After a month's experience in the forward areas, it became evident that the various problems enumerated above markedly reduced the efficiency of the effort. Accordingly, an attempt was made to shift the location of the interviews to the rear areas which included the replacement companies and the airfields which served as Rest and Recreation Headquarters for the line troops.

a. Replacement Company

The replacement companies were rear units of the divisions through which new troops were processed prior to being sent forward to the line organizations. The facilities in these companies were superior to those previously discussed since space limitation was not a serious factor. Usually additional assistance from the cadre personnel readily could be

obtained to expedite the work. The division personnel offices were located in these areas therefore the Army General Classification Test scores on the questionnaires could be secured easily. There were, as might be expected, certain disadvantages which prevailed to hamper the effort. For example, the replacement companies never received advance notice when to expect troop shipments. Therefore, it was impossible to work out a satisfactory interview schedule, and daily calls to the units were required. When a shipment of men arrived, they would be assigned in varying numbers to all units in the area so that interviews could only be accomplished in one unit. A second factor, which prevented the rear areas from being entirely satisfactory, was the policy that existed in different divisions regarding the flow of men through replacement companies. Some divisions used the replacement company locations as training areas and held their men anywhere from 4 to 6 days, while others processed them through in less than 24 hours. In these latter companies, time and availability of men did not permit interviews to be made. A third factor concerned the subsequent assignment of men. There was no

assurance that the men interviewed would all be assigned to front-line units despite their infantry MOS designations.

b. Airfields

An attempt was made to interview men who were awaiting flights to Japan for their 5-day rest and recreation (R & R) leaves. It is admitted that these subjects did experience cold exposure, but none at time of interview had incurred a cold injury and since continued exposure followed the examination these men were included in the study. The men were available for interviews anywhere from 30 minutes to 10 or 12 hours, depending on the availability of planes on any particular day. Since all troops were included in the R & R program, the main problem encountered was the selection of men with the proper MOS designation. Attempts were made to have the various replacement companies screen their troops prior to their arrival at the airfields, but the continual changes in the cadre personnel reduced the efficiency of this procedure.

B. The Pre-Exposure Questionnaire

The questionnaire employed was divided into two main

sections; the first section dealt with general information about the individual while the second section was concerned with certain biological factors. Appendix I represents the form utilized in this survey. Items 1-30 covered the general information area while the remaining nine items represented the biological measures. A brief explanation of the various items is given below.

1. General Information Section

Items 1-10 included the identification data such as name, serial number, date of interview, age, race, rank, place of birth, etc. Item 5 (location) included the organization to which the man was attached, as well as the status of the organization at the time of interview, such as a division or regiment in reserve, a replacement company, etc. Items 11-13 covered the climatological aspects in order that an assessment of these factors could be made in the subsequent analysis. For example, under Item 11 an attempt was made to record information concerning the various place or places the interviewee had lived for at least a winter season during his life, in order to determine the approximate degree of exposure to a cold climate the man may have experienced. Item 14 listed the main civilian occupation of the individual with particular reference as to whether it was an indoor or outdoor job. Items 15-18

covered the use of tobacco, coffee and alcohol with an attempt to obtain a rough index as to the extent of such usage. The importance of these factors was minimized by the situation in the Korean theater where tobacco and beer were rationed to one pack of cigarettes per day per man and approximately four cans of beer per month per man. Item 19 was included in an attempt to elicit a history of the man's previous combat experience, including action in World War II, in order to determine whether or not the individual had had previous experience fighting in cold climates. A history of previous cold injury, including civilian life, was the purpose of Item 20. The criterion in the assessment of this factor necessitated the admission from the interviewee that at least blistering and peeling of tissues had occurred and that medical attention had been sought. Item 21 was used in an attempt to evaluate the effectiveness of previous cold weather training including films, lectures, demonstrations, etc. "Cold weather operations" included bivouac in cold areas during basic training. The information recorded under the category "Other" included previous combat in cold regions or during cold seasons. Items 22 and 23 covered the educational and intelligence factors. Both Area I and Area III Army General Classification

Test (AGCT) scores were recorded under Item 23. These two areas were selected since it was felt they represented a truer estimate of the man's basic intelligence than did any other section of the test. A history of the individual's disciplinary record was obtained under Item 24 in an attempt to assess the factor of malingering and its relationship to frostbite casualties. Item 25 was a history of disease which might conceivably alter the cold hemagglutinin titers. Item 26 was the subjective impression of the interviewee concerning the degree of sweating exhibited by his own feet. Items 27 and 28 were included to determine if unilateral frostbite of the hand could be related to the manipulation of the man's weapon. Item 29 was incorporated to determine if "accident proneness" had any relation to the acquisition of cold injuries. A history of accidents which the examiner felt might reflect this tendency was recorded. Such data as athletic injuries were generally not considered to fall into this category and were ignored. Item 30 concerned the interviewee's hobbies whenever they could be determined from questioning. These data were used to test the hypothesis that men who had done considerable hunting and fishing, including camping, might be better able to care for themselves

under adverse weather conditions.

2. Biological Measures

Item 1, the cold hemagglutinin sample, is discussed in Section XIII of the combined cold injury report. Item 2 was an evaluation by the examiner of the man's personal hygiene based primarily upon an examination of the feet, condition of the clothing, etc. Because of the conditions under which the man were forced to live, the presence of dirt on the feet was minimized, but such conditions as untreated epidermophytosis, untrimmed nails, callouses, etc., were used in assessing this item.

Item 3 is of little importance since the evaluation of body type was based principally on the man's estimate of his own height and weight. It was impossible to have the interviewee strip down for anthropometric measurements and somatotyping photographs since the ambient temperature of the interview site was often about 40° F. Items 4-7 are self-explanatory. However, the recorded height and weight were obtained from statements by the man and not determined by actual measurement. The gross sweat examination was performed by actually feeling the foot with the hand and determining the extent of dryness or wetness. Skin resistance measurements were not accomplished since the necessary instrumen-

tation was not available. Approximately 200 starch-iodine sweat tests were performed with entirely negative results so the procedure was eliminated in subsequent examinations. The insensitivity of the starch-iodide test utilized in this study was demonstrated when examination of the feet with an ophthalmoscope to obtain illumination and magnification revealed the presence of beads of sweat even in the absence of color changes in the starch-iodide paper. The data for Item 9 were obtained by applying moderate pressure with the index finger of the examiner for 10 seconds to the end of the great toe. Upon release of pressure the number of seconds required to re-establish the normal skin color of the digit was recorded. This measure is considered to be quite unreliable since it was not possible to have the subjects equilibrate in a constant temperature room prior to the examination. Consequently the variations in ambient temperature markedly affected the values obtained from day to day.

An attempt was made to train corpsmen in various replacement companies to perform the interviews in the absence of the single examiner who was assigned to the project. This was done with the hope that the total number of questionnaires completed would

be greatly increased. The program proved quite successful in three instances, but time did not permit a completely adequate program to be instituted.

Appendices II and III include samples of the code sheet derived from the questionnaire to facilitate the subsequent IBM analysis.

C. Collection of Blood Samples

The collection of the blood samples and their subsequent shipment to the Cold Injury Research Laboratory at Osaka for cold hemagglutinin analysis presented several problems. The shortage of team personnel made it mandatory that corpsmen be obtained from the various units to assist in the collection phase. Originally 10 cc. syringes were employed for this task, but the absence of suitable cleaning and sterilization equipment in the forward areas necessitated a change in technique. The Shepperd-Keidel blood collecting tubes were employed subsequently with a high degree of success.* These units came sterilized and the blood-filled tubes were packed in 50 caliber ammunition boxes for shipment. Approximately 200 tubes were packed in a single container.

*The Shepperd-Keidel tube consists of a sealed evacuated glass ampule of 5-6 ml. capacity, fitted with a 22 gage venous puncture needle by means of rubber tubing. The needle is protected by a tightly fitting glass cover. This tube may be obtained from the Scientific Glass Inst. Company, North Field, New Jersey.

and the breakage rate was extremely low. The blood samples were taken from the forward areas to an evacuation hospital and from that point were hand-carried by messenger to the laboratory in Japan.

III. RESULTS

A total of 1,628 front-line infantrymen were interviewed during the period 8 November 1951 to 1 February 1952. Of these 1,628 interviews, approximately 1,250 were obtained before the onset of cold weather. An additional 120 interviews were obtained on hospitalized frostbite patients. The interviewer traveled over 7,000 miles by jeep and made some additional trips by plane in the collection of these data.

The population represented by the pre-exposure questionnaires reflected a random sampling of Eighth Army as far as the distribution between Whites and Negroes was concerned. A further breakdown by climatological region of origin indicated that this group did not deviate significantly from the distribution evidenced by the epidemiologic controls and thus were used as another control population for comparative purposes in epidemiologic study.

Since only two of the 1,628 infantrymen interviewed eventually became frostbite casualties, no internal analysis of the pre-exposure data was attempted.

In all, approximately 3,000 blood samples were forwarded to the laboratory in Japan. Of these, only 521

samples were obtained from the pre-exposure population of 1,628 men.

IV. RECOMMENDATIONS FOR FUTURE SURVEYS

Certain specific recommendations are mentioned here which should facilitate the collection of similar data in the future. The delays and difficulties which resulted when one interviewer attempted to cover the entire Korean theater strongly indicated the desirability of having a trained interviewer with two enlisted assistants assigned to each division. Such an arrangement would permit the examining team to set up a semi-permanent site for its work. Travel time between battalions and regiments would be measurably reduced, and work could proceed with minimal interruptions and delay. The two enlisted personnel could not only assist in the filling out of the questionnaires but could also draw the blood samples.

It is suggested that each such interviewing team have its own vehicular transportation, including a jeep and a 1/4-ton trailer. With such an arrangement, each group of interviewers could easily examine at least 50 to 60 men a day and collect up to 200 blood samples. Such an organization would permit the completion of at least 30,000 to 50,000 questionnaires in a 4-month period under conditions comparable to those under which the present study was conducted.

Undue delays occurred in getting blood samples to the laboratory. In some cases periods as long as 10 days elapsed between the drawing of the samples and their analysis. It is believed that such delays can be eliminated in a future program by the assignment of specific messengers to the team.

APPENDIX I

PRE-EXPOSURE QUESTIONNAIRE

PRE-EXPOSURE QUESTIONNAIRE

RECORDER ______________________

(1) NAME ______________________ (2) DATE OF EXAM ______________
(Last) (First) (Middle)

(3) AGE ____________ (4) RACE [W] [N] [M]

(5) LOCATION ______________________

a. Rest Area [ ] b. Repo Depo [ ] c. R & R Airfield [ ]

(6) SERIAL NO. ______________ (7) RANK __________ (8) M.O.S. __________

(9) PLACE OF BIRTH ______________ (10) DATE OF BIRTH ______________

(11) OTHER PLACES LIVED IN FOR AT LEAST ONE WINTER SEASON: ______________

____

____

____

(12) TYPE OF AREA LIVED IN FOR GREATER PART OF LIFE:

a. City [ ] b. Suburban [ ] c. Rural [ ]

(13) COLDEST TEMPERATURE TO WHICH EXPOSED:

a. Approx. Temp. °F. __________ b. Approx. Length of Time __________

c. Environment: Indoors Mostly [ ] Outdoors Mostly [ ]

(14) CIVILIAN OCCUPATION ______________________

(15) SMOKING: a. PIPES [0] [1-3] [4-6] [7-9] [[illegible] 10 [illegible]] (per day)

b. CIGARS [0] [1-2] [3-4] [5-6] [[illegible] 6] (per day)

c. CIGARETTES [0] [1/2] [1] [2] [[illegible]] [[illegible] PACKS] (per day)

(16) TOBACCO CHEWING: (Amount in Plugs) [0] [1-2] [3-4] [5-6] [MORE THAN 7] (per wk.

(17) COFFEE: (Cups per Day) [0] [1-3] [4-6] [7-9] [10-12] [OVER 12]

(18) ALCOHOL INTAKE PER WEEK, BEER (Bottles) [[illegible]] [[illegible]] [[illegible]] [[illegible]] [[illegible]] [[illegible]]

(19) COMBAT EXPERIENCE: [YES] [NO]

a. WHEN ______________ b. WHERE ______________

(20) COLD INJURY: (Frostbite, Chilblains, French Foot, etc.) [yes] [no]

a. Anatomical Site ______________________

b. When Occurred ______________ c. Where Occurred ______________

d. Activity at Time of Injury ______________________

(21) COLD WEATHER TRAINING: [Yes] [No]

a. When ______________ b. Where ______________

c. Type of Training:

Lecture	[ ]
Film	[ ]
Demonstration	[ ]
Cold Weather Operation	[ ]
Other	[ ]

d. Amount of Instruction: [ ]

(22) HIGHEST SCHOOL GRADE COMPLETED: [1] [2] [3] [4] [5] [6] [7] [8] [9] [10] [11] [12]

[13] [14] [15] [16] [17] [18] [19] [20]

(23) INTELLIGENCE RATING ______________ (ACCT - area 3 score)

(24) DISCIPLINARY RECORD:

	NO.	OFFENSE	SENTENCE
Company Punishment	[ ]		
Summary Court Martial	[ ]		
Special Court Martial	[ ]		
General Court Martial	[ ]		

(25) DISEASES: AGE:

Malaria

Yellow Jaundice

Pneumonia

Unexplained Fever (Infectious Mononucleosis, etc.)

Tuberculosis

Syphilis

Hematuria (Red or Dark Urine)

Raynaud's Disease

(26) [illegible] [illegible] [illegible] [illegible]

(27) DO YOU CONSIDER YOURSELF RIGHT OR LEFT HANDED? [R] [L]

(28) WHICH HAND DO YOU USE TO PULL THE TRIGGER? [R] [L]

(29) HISTORY OF ACCIDENTS (Any accident requiring medical attention such as serious sprains, broken bones, etc.)

____

____

____

(30) HOBBIES (Particularly outdoor activities such as camping, hunting, fishing, etc.)

____

OBSERVATIONS ON ALL PATIENTS

(1) COLD AGGLUTININ SAMPLE (10 cc.) TIME TAKEN: ____________

TITER: ____________ ANALYST: ____________ DATE: ____________

(2) PERSONAL HYGIENE (Based on Cleanliness and Neatness, particularly feet)

EXCELLENT [ ] GOOD [ ] POOR [ ]

(3) BODY TYPE ECTOMORPH [ ] ECTO-MESO MORPH [ ]

MESOMORPH [ ] MESO-ENDO MORPH [ ] ENDO-MORPH [ ]

(4) HEIGHT: ____________

(5) WEIGHT: ____________

(6) PULSE RATE AT REST: ____________

(7) ORAL TEMPERATURE: ____________

(8) SWEAT: ____________

GROSS EXAM LIGHT [ ] MODERATE [ ] HEAVY [ ]

SKIN RESISTANCE: (Taken on Instep) [ ]

STARCH-IODINE TEST: RATING [ ]

(9) BLOOD FLOW: (Return of skin color after 10 sec. pressure on end of great toe)

SECONDS [ ]

REMARKS: ______________________________

____

____

APPENDIX II

CODE SHEET FOR PRE-EXPOSURE QUESTIONNAIRE

CODE SHEET FOR PRE-EXPOSURE QUESTIONNAIRE

NAME ______________________ RECORDER ______________________

CHECKER ______________________

1-4. IDENTIFICATION

[ ]

5-12. SERIAL NUMBER

00000000. No data

[ ]

13-16. DAY AND MONTH OF INTERVIEW

0000. No data

[ ]

17. DIVISIONS

Y. 40th Div.
0. No data
1. 1st Cav. Div.
2. 1st Mar Div.
3. 2nd Div.
4. 3rd Div.
5. 7th Div.
6. 24th Div.
7. 25th Div.
8. Misc. 8th Army Units
9. 45th Div.

18. REGIMENTS

0. No data
1. 5th Cav, 1st Mar, 9th, 7th, 17th, 5th 14th, 160th, 180th
2. 7th Cav, 5th Mar, 23rd, 15th, 31st, 19th 27th, 223rd, 179th
3. 3th Cav, 7th Mar, 38th, 65th, 32nd, 21st, 35th, 224th, 279th
4. 11th Mar
5. Sep Units of Div.
6. British Commonwealth
7. French
8. Ethiopian
9. Greek

19. BATTALIONS

0. No data
1. 1st Bn
2. 2nd Bn
3. 3rd Bn
4. Eng. Bn (Sep)
5. Other Sep Bn

20-21. AGE (Last Birthday)

00. No data

[ ]

22. INTERVIEW SITE

0. No data
1. Div. in Reserve
2. Reg. in Reserve
3. Bn. in Reserve
4. Replacement Co. (new replacement)
5. Replacement Co. (R&R)
6. K-16 (R&R)
7. Annex II Patients
8.
9.

23. RANK

0. No data
1. Private
2. PFC
3. Cpl.
4. Sgt.
5. Sgt. 1/C
6. M/Sgt.
7. Commissioned Off.
8.
9.

24. RACE

1. White
2. Negro
3. Mongolian

25-26. MOS

00. No data

[ ]

27-28. STATE OF BIRTH

00. No data

[ ]

29. CLIMATOLOGICAL REGION OF BIRTH STATE

0. No data

[ ]

30. CLIMATOLOGICAL REGION LIVED IN LONGEST PERIOD

0. No data

[ ]

31. CLIMATOLOGICAL REGION LIVED IN 2nd LONGEST PERIOD

0. No date
Y. None

[ ]

32. CLIMATOLOGICAL REGION LIVED IN 3rd LONGEST PERIOD

0. No data
Y. None

[ ]

33. RESIDENCE OUTSIDE CONTINENTAL LIMITS

0. No data
Y. None

34. TYPE OF HABITAT GREATER PART OF LIFE

0. No data
1. Rural
2. Suburban
3. City
4. Rural & Suburban
5. Rural & City
6. Suburban & City
7.
8.

35. COLDEST TEMP °F EXPOSED

0. No data
1. Above 32°
2. 22 to 32°
3. 12 to 22°
4. 2 to 12°
5. -8 to 2°
6. -18 to -8°
7. -28 to -18°
8. -38 to -28°
9. Below -38°

36. LENGTH OF EXPOSURE

0. No data
1. None
2. Less than 1 day
3. 1-2 days
4. 2-3 days
5. 3-7 days
6. Over 7 days

37. ENVIRONMENT DURING COLD SPELL

0. No data
1. None
2. Outdoors mostly
3. Indoors mostly
4. Approx. equal time indoors & outdoors
5.
6.
7.
8.

38-40. CIVILIAN OCCUPATION

000. No data

41. SMOKING - PIPE (Bowls/day)

0. No data
1. None
2. Less then 1 bowl
3. 1-3 bowls
4. 4-6 bowls
5. 7-9 bowls
6. 10 bowls
7. Over 10 bowls

42. SMOKING - CIGARS (No./day)

0. No data
1. None
2. Less than 1 cigar
3. 1-2 cigars
4. 3-4 cigars
5. 5-6 cigars
6. 7-8 cigars
7. More than 8 cigars

43. SMOKING - CIGARETTES (Packs/day)

0. No data
1. None
2. Less than 1/2 pack
3. 1/2 pack
4. 1 pack
5. 1-1/2 packs
6. 2 packs
7. 3 packs
8. More than 3 packs

44. TOBACCO CHEWING (Plugs/week)

0. No data
1. None
2. 0-1 plug
3. 1-2 plugs
4. 3-4 plugs
5. 5-6 plugs
6. More than 7 plugs

45. COFFEE INTAKE (Canteen cups/day)

0. No data
1. None
2. Less than 1 cup
3. 1-3 cups
4. 4-6 cups
5. 7-9 cups
6. 10-12 cups
7. Over 12 cups

46. BEER INTAKE (Cans/week)

0. No data
1. None
2. Less than 1 can
3. 1-2 cans
4. 3-4 cans
5. 5-6 cans
6. 7-8 cans
7. 9-10 cans
8. 10-12 cans

47. COMBAT EXPERIENCE

0. No data
1. None
2. WW II-European & N. Africa
3. WW II-So. Pac.
4. WW II-Alaska
5. WW II-Iceland & Greenland
6. WW II-Japan
7. WW II-CBI
8. Korea
9. WW II & Korea

48. PREVIOUS COLD INJURY

0. No data
1. None
2. Frostbite
3. Trenchfoot
4. Chilblain
5. Frostbite & Trenchfoot
6. Frostbite & Chilblain
7. Trenchfoot & Chilblain
8.
9.

49. ANATOMICAL SITE OF COLD INJURY

0. No data
1. None
2. Rt Hand only
3. Lt Hand only
4. Rt Foot only
5. Lt Foot only
6. Both Feet
7. Both Hands
8. Both Hands & Feet
9. Ears, Nose, etc.

50-51. YEAR OF INJURY

00. No data
10. None

[ ]

52-53. STATE OR PLACE WHERE INJURY OCCURRED

00. No data
99. None

[ ]

54-55. ACTIVITY AT TIME OF INJURY

00. No data
99. None

[ ]

56. TYPE OF COLD WEATHER TRAINING

0. No data
1. None
2. Lectures
3. Films
4. Clothing Demonstrations
5. Cold Weather Operations
6. Combat in Cold Regions
7. More than 1 of above
8.
9.

57. NUMBER OF LECTURES

0. No data
1. None
2. 1-2
3. 3-4
4. 5-6
5. 7-8
6. 9-10
7. 11-12
8. Over 12
9.

58. NUMBER OF FILMS

0. No data
1. None
2. 1-2
3. 3-4
4. 5-6
5. 7-8
6. 9-10
7. 11-12
8. Over 12
9.

59. NUMBER OF DEMONSTRATIONS

0. No data
1. None
2. 1-2
3. 3-4
4. 5-6
5. 7-8
6. 9-10
7. 11-12
8. Over 12
9.

60. COLD WEATHER OPERATIONS

0. No data
1. None
2. 1-2
3. 3-4
4. 5-6
5. 7-8
6. 9-10
7. 11-12
8. Over 12
9.

61-62. TOTAL AMOUNT OF INSTRUCTION

00. No data
99. None

[ ]

63-64. HIGHEST SCHOOL GRADE COMPLETED

00. No data

[ ]

65-67. AGCT SCORE AREA I

000. No data

[ ]

68-70. AGCT SCORE AREA III

000. No data

[ ]

71. MILITARY DISCIPLINARY RECORD

0. No data
1. None
2. Company Punishment
3. Summary Court Martial
4. Special Court Martial
5. General Court Martial
6. More than 1 Company Punishment
7. More than 1 Summary CM
8. More than 1 Special CM
9. More than 3 of above

72. HISTORY OF PREVIOUS ILLNESSES

0. No data
1. None
2. Malaria
3. Jaundice
4. Pneumonia
5. Undiag. Fevers
6. Tuberculosis
7. Syphilis
8. Hematuria
9. More than 1 of above

73. PATIENTS ESTIMATE OF FOOT SWEATING

0. No data
1. None
2. Light
3. Moderate (Avg.)
4. Heavy

74. HANDEDNESS

0. No data
1. Right
2. Left
3. Ambidextrous

75. TRIGGER HAND

0. No data
1. Right Hand
2. Left Hand
3. Either Hand

76. ACCIDENT PRONENESS

0. No data
1. None
2. 1-2
3. 3-4
4. 5-6
5. 7-8
6. 9 or over
7. Athletic injuries only
8. Accidents and athletic injuries
9.

77-78. HOBBIES

00. No data
53. None

80. CARD DESIGNATOR

0. Quartermaster
1. Pre-Exposure Quest.
2. Pre-Exposure Biological
3. Epidemiological Control
4. Study Patient
5. Routine Patient
6. ICC
7. Laboratory Patient
8. Laboratory Control
9. Pre-Exposure Control

APPENDIX III

CODE SHEET FOR PRE-EXPOSURE BIOLOGICAL SURVEY

CODE SHEET FOR PRE-EXPOSURE - BIOLOGICAL SURVEY

NAME ______________________ RECORDER ______________________

CHECKER ______________________

1-4. IDENTIFICATION NUMBER

0000. No data

5-12. SERIAL NUMBER

00000000. No data

13. PERSONAL HYGIENE

0. No data
1. Excellent
2. Good
3. Poor

14. BODY TYPE

0. No data
1. Ecto-morph
2. Ecto-mesomorph
3. Mesomorph
4. Meso-Endo Morph
5. Endo Morph
6.
7.
8.
9.

15-16. HEIGHT IN INCHES

00. No data
01. Below 60
02. 60
03. 61
04. 62
05. 63
06. 64
07. 65
08. 66
09. 67
10. 68
11. 69
12. 70
13. 71
14. 72
15. 73
16. 74
17. 75
18. 76
19. Over 76

17-19. WEIGHT IN POUNDS

000. No data

20-22. PULSE RATE/MIN (RESTING)

000. No data

23-25. ORAL TEMPERATURE

000. No data

26. GROSS SWEAT EXAM

0. No data
1. Light
2. Moderate
3. Heavy
4.
5.
6.

27-28. BLOOD FLOW - SECONDS PRESSURE ON GREAT TOE

00. No data

29-30. COLD AGGLUTININ TITER - A

00. No data
01. Negative
02. 1:2
03. 1:4
04. 1:8
05. 1:16
06. 1:32
07. 1:64
08. 1:128
09. 1:256
10. 1:512
11. 1:1024
12. 1:2048 and over

31-32. AGE OF SAMPLE (DAYS)

00. No data

80. CARD DESIGNATOR

0. Quartermaster
1. Pre-Exposure Quest
2. Pre-Exposure Biological
3. Epidemiological Control
4. Study Patient
5. Routine Patient
6. ICC Patient
7. Laboratory Patient
8. Laboratory Control
9. Pre-Exposure Control

ARMY MEDICAL RESEARCH LABORATORY

FORT KNOX, KENTUCKY

REPORT NO. 113
1 April 1953

COLD INJURY - KOREA 1951-52*

Section IV
EPIDEMIOLOGY OF FROSTBITE, KOREA, 1951-52

*Subtask under Environmental Physiology, AMRL Project No. 6-64-12-028, Subtask (8K), Cold Injury Studies.

MEDICAL RESEARCH AND DEVELOPMENT BOARD
OFFICE OF THE SURGEON GENERAL
DEPARTMENT OF THE ARMY

RESTRICTED
Security Information

SECTION IV

EPIDEMIOLOGY OF FROSTBITE
KOREA, 1951-52

by

Leonard M. Schuman
Cmdr., Senior Surgeon, USPHS

RESTRICTED
Security Information

TABLE OF CONTENTS

TABLE OF CONTENTS (Cont.)

RESTRICTED
Security Information

RESTRICTED
Security Information

EPIDEMIOLOGY OF FROSTBITE

KOREA, 1951-52

I. INTRODUCTION

Epidemiology is the study of the mass phenomena of disease. Its principles were developed as an approach to the understanding and measurement of the interrelationships between the agents of disease and the host whose receptivity is modified by varying environmental factors. It was only natural that epidemiologic principles should first have been applied to the communicable diseases, for the dynamic changes involved in acute outbreaks or epidemics of infectious disease were dramatic, fairly obvious and, in many cases, readily measurable. Moreover, these diseases drew attention to themselves by their rapid and frequently cyclic production of excess mortality. Small wonder then that epidemiology saw its birth and development in the infectious diseases. Chronic disease, with its less dramatic and insidious progress, its endemicity as opposed to acute or epidemic outbreaks and the cublety of its etiology, did not receive epidemiologic attention until relatively recent years (1, 2, 3).

The application of this regimen to the study of trauma was inevitable (4), for the techniques of epidemiology are designed to assess environmental modifying factors, mode of application of the etiologic agent and variations in host susceptibility irrespective of the form or character of the etiologic agent itself (5). Only the agent varies radically in form in the host-agent-environment complex. Yet this variance is superfical for the end result of the application of any

agent is damage to tissue, whether it be the toxin of the diphtheria bacillus in a susceptible child living in a crowded institution, a moving part of an unprotected piece of machinery on the hand of a stamp-mill operator in industry, arsine gas inhaled unsuspectingly by workers in lead-reclaiming processes or freezing temperatures on front-line infantrymen pinned down by enemy fire on a patrol. Whayne (6) has set forth the parallelisms between the host-parasite-environment relationship in infectious disease and the host-agent-environment complex in trauma such as cold injury. He also has demonstrated the fruitfulness of the epidemiologic approach to the study of one type of cold injury, namely, trenchfoot.

The Korean War has afforded an opportunity to study another and more severe type of cold injury, frostbite. Orr and Fainer (7) have described such mass trauma. Both of these authors and Whayne have posed several significant problems in the evaluation of the relationship between the agent, cold, the host, the front-line rifleman and the environmental factors.

Epidemiology should, then, be more properly redefined as the study of the mass phenomena of disease or trauma, i.e. the knowledge of the agent, modifying host and environmental factors and their interrelationships. Since the goal of epidemiology is prevention and since cold injury remains an important problem in military operations the assessment of these relationships takes on a special significance if the problem is to be resolved or at least reduced to an insignificant minimum. Some cold injury probably always will occur, for even with a perfect heat-retaining and ventilating combat uniform and nearly

perfect hand and footgear, extenuating circumstances of duration of exposure, pinning enemy fire, damage to clothing, extreme personal neglect and poor command, to name but a few, will operate from time to time to produce an endemic incidence of cold injury. These relationships must be appraised to the end that the incidence of such injuries will be maintained at or near the irreducible minimum.

II. THE PROBLEM

In the communicable diseases three points of attack are possible though not always practical in control. The agent (or its reservoir) can be eradicated as in the destruction of tuberculous cattle. Its transmission can be interrupted as in the isolation of cases of infectious disease or as in the eradication of the vector (for example the anopheline mosquito in malaria). Finally the susceptibility of the host can be reduced by providing adequate nutrition and maintaining healthy physiologic processes thus enhancing his resistance by developing an active acquired immunity.

In cold injury the agent cannot, unfortunately, be eradicated, for as long as warfare is conducted in cold climates, low temperatures will always be operative. Again, the agent cannot be isolated unless the locale for such warfare is avoided. However, an attempt can be made to interfere with the "transmission of the agent" by reducing heat loss in every conceivable way. This may be done by increasing host resistance by enhancing whatever factors contribute to this resistance, or reducing susceptibility by minimizing or abolishing those factors which increase the susceptibility of the host.

At the end of World War II certain pertinent problems in cold

injury remained unanswered (6). To mention a few, low temperature as the agent had not been completely explored and quantitated in establishing a gradient of injury, nor had attempts at measuring predictability from anticipated temperatures been successful. The relation of duration of exposure to temperature as an index to injury had not been delineated and the synergistic effect of wetness had not been completely evaluated.

Similarly, factors modifying host resistance or susceptibility remained to be quantitated and their interactions assessed. Among these are previous cold injury, nutrition, fatigue as a product of the intensity and duration of stress, training, race, geographic origin and possible acclimatization, inherent constitutional factors and such psychosocial factors as morale, motivation and intelligence.

The socioeconomic aspects of environment also were not without their unanswered or inadequately defined problems. The role of intensity of combat activity remained an elusive quantitation as did shelter, clothing, foot discipline, leadership and unit experience.

Thus the studies of the European Theatre of Operation begged not only for repetition in application to frostbite but also for extension in the hope of clarifying at least a few of the relationships. The Korean conflict thus became the field study laboratory in the epidemiologic approach to cold injury.

In the winter of 1950-51 a systematic attempt to analyze the multiple factors contributing to mass frostbite in military operations was made (7). In the winter of 1951-52 a more detailed study directed at quantitating and clarifying the roles of the several modifying factors

was undertaken. This report deals with the latter epidemiologic inquiry.

III. OBJECTIVES

The principle objectives of this epidemiologic study included:

1) A general description of the over-all frostbite incidence and its relation to the military problem.

2) The delineation and assessment of the multiple factors modifying the host-agent relationship in cold injury.

3) The determination of those factors or attributes which determine that one soldier shall be traumatized by low temperatures, while another escapes although both are subjected to the same stress in time and place.

4) As an outgrowth of these studies, the recommendation of certain measures to be applied toward the prevention or at least the minimization of cold injury among troops operating in subarctic or arctic climates.

IV. GENERAL DESCRIPTION OF THE LOCALE

The Korean terrain encompassing the Main Line of Resistance is mountainous with narrow valleys on the east but with lower hills and broader valleys on the west. Rivers are shallow except during the spring freshets and summer rains. The climate has been described in Section I of this report and the temperature ranges pertinent to this analysis will be discussed below. The repeated forward and retrograde movements of combatant forces have produced devastation of villages in the battle zone, thus rarely providing shelter in native huts and buildings.

During the winter of 1951-52 the first cold weather found the United Nations troops on a stabilized line. Heavy combat was less frequent. Most of the troops were in bunkers and well-developed foxholes, although several units found themselves enlarging foxholes and building bunkers in sectors previously held by South Korean (ROK) troops. Except for sporadic enemy attacks of regimental size during this interchange of troops positions, when the temperatures began dropping and snow began to fall, the action along the front was relatively minimal and was characterized predominantly by patrolling and line holding in static defense. This was in marked contrast to the active offense and retrograde movement preceding the Hungnam evacuation in the winter of 1950-51. Combat activity in its full range did not occur in the winter of 1951-52 and its role in the production of frostbite could not be completely measured. A front engaged in static defense did present relative stability or constancy of environment and activity so that other variables of host-agent relationships could more readily be analyzed. Such action permitted "on-the-line" investigation of factors leading to cold injury and the careful selection of "bunker-mate" controls.

V. METHOD OF SURVEY

Field conditions rarely permit the control of one variable so that variations in others may be observed. Nor is it always desirable to do this for the "normality" of interactions are interfered with and the true relationships between factors obscured. The survey approach may elicit data in vertical (cross-sectional) or longitudinal (a continuum in time) fashion. It is a useful tool and, when applied prior

to, concurrent with and following an incident or incidents, will preserve the "normal" relationships in their true perspective and permit valid interpretations.

The survey approach was applied to this epidemiologic study for both cases and controls. A standard code sheet (see General Summary) was utilized for both groups. Interviewing was on the basis of predetermined standards and question content and this, for the most part, minimized differences in technique. Such differences in technique are described in the pertinent sections in which they occur. The epidemiologic controls were interviewed in all instances by the author with but few exceptions. These exceptions included the controls of the 65th Regiment (Puerto Rican) who were interviewed by a Spanish-speaking Preventive Medicine Officer and those of the Thailand Battalion and Ethiopian Forces who were interviewed by their respective battalion surgeons. These officers were oriented and indoctrinated intensively in the objectives of the survey and the proper use of the code sheet.

Since cold injury had been shown to be primarily an occupational disease of front-line riflemen (6, 7) the evaluation of factors contributing to excess cold injury in this group would preferably be predicated upon comparisons with suitable controls, drawn as a sample from the smallest possible functional units so that the geographic location, time of exposure and general type of activity for both case and control would be identical. In this way similarity or identity of stress for the two groups would be achieved. This method of selection has led to the term "bunker-mate" controls for the control group. This approach had as its goal, the explanation for the occurrence of frostbite in

one individual and not in another under identical stress.

With each outbreak of frostbite cases, the divisions contributing to the case load were visited and vital data were obtained on each case. This included the unit of origin, race and approximate time of injury. Conferences were then arranged with regimental and battalion surgeons and unit commanders (battalion or company) for purposes of determining the exact activity and location and, as accurately as possible, the time of onset of the patient's injury. With this information confirmed by unit records the control subject for interview was then selected from the same squad or bunker from which the case originated. Thus, if frostbite was incurred on a patrol, the control to be selected had to be on the same patrol, in the same location and engaged in virtually the same general activity as the case. If injury occurred on a vehicle, the control selected was a member of the same trip on the same vehicle; if on the Main Line of Resistance in a foxhole or bunker, a foxhole mate or bunker-mate. A comparison of distributions by unit and combat role for cases and bunker-mate controls is presented in Tables 1 and 2, respectively. Because of the small percentage of Negro troops in front-line units (9.0%) the control group revealed a race distribution similar (8.1%) to the front as a whole rather than reflecting the relative incidence (Table 3). This becomes understandable when it is realized that a squad-sized patrol with one Negro would have no Negroes left for interviewing if cold injury claimed the one. Since selection of controls was primarily on the basis of similarity of stress a race for race selection could not be made. This is not a defect as will be described under "Race" below.

RESTRICTED
Security Information

TABLE 1

DISTRIBUTION OF 716 UNITED STATES CASES OF FROSTBITE
ACCORDING TO UNIT AND COMBAT ROLE

Unit	Number of Cases					
	Total		Infantry Battalions		Other Divisional Units	
	No.	% of Grand Total	No.	% of Division Total	No.	% of Division Total
1st Cavalry Division	9	1.3	8	88.9	1	11.1
1st Marine Division	10	1.4	8	80.0	2	20.0
2nd Infantry Division	24	3.4	14	58.3	10	41.7
3rd Infantry Division	98	13.7	88	89.8	10	10.2
7th Infantry Division	200	27.9	179	89.5	21	10.5
24th Infantry Division	76	10.6	63	82.9	13	17.1
25th Infantry Division	47	6.6	33	70.2	14	29.8
40th Infantry Division	64	8.9	55	85.9	9	14.1
45th Infantry Division	125	17.5	93	74.4	32	25.6
Total in Divisions	653	91.3	541	82.8	112	17.2
Misc. 8th Army Units	55	7.7	—	—	—	—
Unit Unknown	8	1.1	—	—	—	—
Grand Total	716	100.1				

RESTRICTED
Security Information

RESTRICTED
Security Information

TABLE 2

DISTRIBUTION OF 455 BUNKER-MATE CONTROLS
ACCORDING TO UNIT AND COMBAT ROLE
KOREA, 1951-52

Unit	Number of Controls					
	Total		Infantry Battalions		Other Divisional Units	
	No.	% of Grand Total	No.	% of Division Total	No.	% of Division Total
3rd Infantry Division	57	12.5	57	100.0	-	-
7th Infantry Division	162	35.6	162	100.0	-	-
24th Infantry Division	47	10.3	39	83.0	8	17.0
25th Infantry Division	14	3.1	13	92.9	1	7.1
40th Infantry Division	58	12.8	51	87.9	7	12.1
45th Infantry Division	117	25.7	87	74.4	30	25.6
Total	455	100.0	409	89.9	46	10.1

TABLE 3

DISTRIBUTION OF 716 CASES OF FROSTBITE AND
455 BUNKER-MATE CONTROLS ACCORDING TO RACE
KOREA, 1951-52

Race	Cases		Controls	
	No.	%	No.	%
White	417	58.2	407	89.5
Negro	291	40.6	37	8.1
Mongolian	8	1.1	11	2.4
Total	716	99.9	455	100.0

Sufficient time was taken with each subject to establish rapport and assure him the interview was confidential and unrelated to any

RESTRICTED
Security Information

command investigation. Every effort was made to fix the incident in the subject's mind to facilitate recall of details. For example, this frequently involved refreshing the subject's memory on the tactical details of the patrol and using area maps in tracing the specific activity. An attempt was made to interview control subjects as soon as possible after cases occurred. In no instance did more than 3 weeks elapse. As an indication of the general reliability of the data collected in this fashion there may be mentioned that for 455 instances, only in 26 or 5.7% were disparities noted. These were corrected according to the more reliable information of the unit commander or medical corpsman. Subjects were usually interviewed in the relative privacy of battalion aid stations, regimental collecting stations or in forward bunkers without the presence of their commanding officers.

Further data for comparative purposes were derived from the pre-exposure studies independently conducted on a cross-section of front-line replacements. These served as a sample of the front as a whole and will be referred to as pre-exposure controls.

Data relative t unit strength, incidence of battle casualties, non-battle injuries and specific disease admissions were obtained from the statistical office of Eighth Army Medical Section. Data on unit geographic dispositions, tactical deployment and grading of activity were obtained from the Historical Section of Operations (G-3) Eighth Army Headquarters. Grading of activity for regimental units was based on the color-code technique of the Historical Section and included: patrol with enemy contact, patrol without enemy contact,

light action (elements less than one battalion involved), moderate action (elements of one battalion or portions of two or more battalions involved) and heavy action (all elements of two or more battalions involved).

VI. INCIDENCE

A. General

The winter campaign of 1951-52 in Korea yielded fewer cases of frostbite than did the operations during the previous winter. The disparity in the two series can readily be accounted for by the relatively more quiet and static front in 1951-52 as compared to the active offense and defense and rapid retrograde movements in 1950-51, the colder zone of combat operations in 1950-51 (see Meteorologic Section) and the more adequate clothing supply in 1951-52 (see Quartermaster Section).

A total of 1,044 cases of frostbite was officially recorded among United Nations troops in Korea in the winter of 1951-52. Of these, the majority (716) occurred in the United States Eighth Army (Table 4) and represented, with those of the Ethiopian Expeditionary Forces, Thailand Battalion, Colombian Battalion and Philippine Expeditionary Forces, the cases confirmed by the Cold Injury Research Team.

B. Relative Attack Rates for the United Nations Forces

The over-all United States Eighth Army rate was 3.04 per 1,000 strength for the entire period in which cold injury

occurred. In comparing the incidence rates among the several component United Nations forces one is immediately struck with the much lower rate (0.93 per 1,000) for the ROK troops.

TABLE 4

TOTAL INCIDENCE OF UNITED NATIONS FROSTBITE CASES IN KOREA, WINTER OF 1951-52, ACCORDING TO COUNTRY OF ORIGIN OF TROOPS

Country	No.	%	Period rate per 1000
United States (8th Army)	716*	68.6	3.04
South Korea (ROK)	228	21.8	0.93
Ethiopia (Expeditionary Force)	42*	4.0	33.65
Thailand (Battalion)	30*	2.9	21.47
United Kingdom (Commonwealth Div.)	17	1.6	0.90
Colombia (Infantry Battalion)	10*	1.0	9.24
Philippines (Battalion Combat Team)	1*	0.1	0.72
Belgium (United Nations Forces)	0	-	-
France (Infantry Battalion)	0	-	-
Greece (Expeditionary Force)	0	-	-
Netherlands (Detachment)	0	-	-
Turkey (Armed Forces Command)	0	-	-
Total	1044	100.0	2.07

* Confirmed by Cold Injury Team

The question of relative susceptibility or acclimatization immediately arises. Are the South Koreans more "immune" to cold by having lived primitively in this terrain for centuries? In this regard, attention must be called to the fact that the Korean winter climate does not differ significantly from the climate of Northeastern United States. How, then, can one account for this disparity? In the opinion of the authors the incidence figure for ROK troops was not reliable.

There was reason to believe that the bulk of first degree and a not insignificant number of second degree cases either

never came to medical attention or were not evacuated from the front lines. Assuming that the official incidence data were lacking only in first degree cases and correcting for ROK divisions on the Main Line of Resistance only (excluding the divisions in training and those engaged in Operation Ratkiller - guerrilla warfare in Southwest Korea) the corrected incidence rate becomes 2.51 per 1,000 for the entire experience which begins to approach the incidence in the Eighth Army as a whole. Personal field observation seemed to indicate that poorer bootgear was being worn by the ROK troops. This would normally operate in the direction of producing more cold injury and a lower figure would lend some support to the theory of greater resistance to cold among the Koreans. However since adequate data relative to bootgear and other clothing were not available for quantitation, correction for this factor was not possible. Thus substantiation of any hypothesis of difference in susceptibility is difficult.

Attention is next directed to the low incidence of frostbite among United Kingdom troops. A cursory comparison of the rate (0.9 per 1,000)* to the over-all Eighth Army rate was of course not valid for the latter includes army and corps support. Reference to Table 5 reveals a rate of 5.95 per 1,000* for all United States divisions. The British Commonwealth Division rate was thus approximately one-sixth

* For total 5 month period.

of the total United States divisional rate. Comparison, however, with individual divisional rates (Table 6) placed the British Commonwealth Divison at about the level of the United States 2nd Infantry Division (1.2 per 1,000)*. One reason which may be advanced for this low rate was the significantly higher average minimum temperatures to which the British Commonwealth Division was exposed in occupying the southwest anchor of the line as compared to the United States divisions. In addition, the intensity of combat in this sector was milder than for most other sectors along the front.

The Ethiopian Expeditionary Force, a battalion size contingent, had the highest incidence of fro tbite in this experience when compared with the Eighth Army as a whole (Table 4). Even when equalization for size of unit was considered this unit had approximately three times the rate of the average United States battalion (Table 5). This rate was exceeded only by one United States battalion (2nd Bn., 17th Reg., 7th Div.) the bulk of whose injuries occurred while wearing leather combat boots in a snowstorm during an enemy attack. Because of language difficulties, it was not possible to assess contributory factors in this situation. The Ethiopian Force came from similar terrain in their native land with a wide range of temperature extremes. It is presumed, but not claimed, that poor orientation, lack of cold weather training and experience, inadequate utilization of gear and enemy attack contributed

* For total 5 month period.

TABLE 5

COMPARISON OF TOTAL FROSTBITE ATTACK RATES FOR THE SEVERAL ECHELONS IN THE UNITED STATES 8TH ARMY
KOREA, 1951-52

Unit	Attack Rate/1000	(a) % of 8th Army Cases	(b) % Strength in Army	(a/b) Ratio of Actual Rates to Expected Rates	(c) % of Division Cases	(d) % Strength in Divisions	(c/d) Ratio of Actual Rates to Expected Rates	(e) % of Regt. Cases	(f) % Strength in Regt.	(e/f) Ratio of Actual Rates to Expected Rates
8th Army	3.04	100.0	100.0	1.00	-	-	-	-	-	-
Divisions	5.95	92.2	47.2	1.95	100.0	100.0	1.00	-	-	-
Regiments	8.78	81.2	28.1	2.85	88.1	59.7	1.48	100.0	100.0	1.00
*Battalions	11.79	76.4	19.7	3.88	82.8	41.8	1.98	94.1	70.1	1.34

* Infantry Battalions only (rifle and heavy weapons companies)

to this excess morbidity. The role of race is not clear but it must be borne in mind in view of the significant excess morbidity among United States Negro troops. This factor may have predominated for the Ethiopians as well.

The Thailand Battalion received replacements during a severe drop in temperature. They had the misfortune of having to move during a snowstorm with several vehicles breaking down and slowing the convoy. This group came directly from Thailand with its subtropical temperatures to a subarctic zone. They had no previous cold weather training or orientation in the use of cold weather gear and the need for muscular movement when immobilized in cold. Their over-all period rate was twice that for the average United States battalion.

The Colombian Battalion experienced a rate about equal to the average United States battalion rate of cold injury.

C. Monthly Incidence

The first outbreak of frostbite in the winter of 1951-52 in Korea occurred late in November. This first peak of injuries not only was the largest peak of the winter season but constituted 34% of the entire Eighth Army experience (Fig. 1). The entire month of December produced less than one-third the number of injuries which occurred in the last week in November even though the means of the average daily temperatures were virtually identical in the two periods and the mean minimum temperature 2 degrees (F.) colder in December (Appendix Table 1). The majority of injuries in November occurred in two divisions

RESTRICTED
Security Information

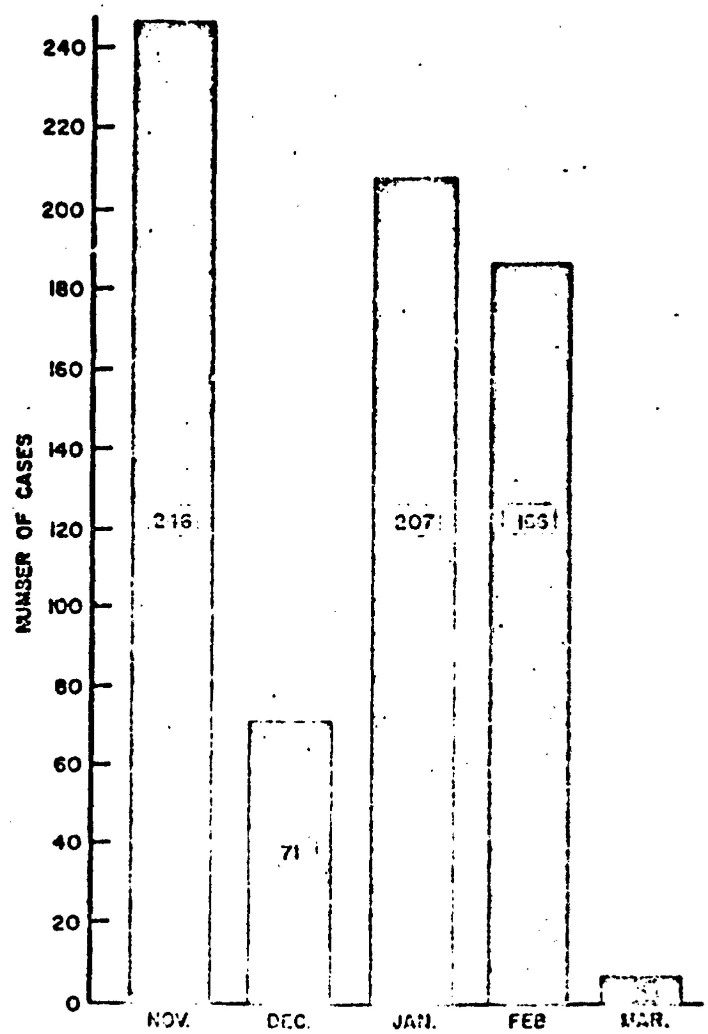


FIG. 1. MONTHLY INCIDENCE OF FROSTBITE U.S. 8th. ARMY KOREA, 1951-52.

RESTRICTED
Security Information

and, more specifically, in three regiments engaged in taking over ROK positions. While attempting to enlarge foxholes and bunkers the enemy attacked the battalion positions with regimental-size forces. The troops had gone into their new positions wearing leather combat boots because of favorable weather. The enemy struck as temperatures declined and snowstorms developed. This was the first cold period of the winter.

Blair and Dimitroff (8) have postulated a lack of acclimatization at the onset of cold weather pointing to a similar massive outbreak of injuries at the onset of cold weather in the Korean winter of 1950-51. The data of both seasons supports such a view, but it is obvious that combat activity with its immobilizing action and inadequate bootgear manifestly contributed to the excess incidence.

January and February increases in incidence were primarily temperature effects on an otherwise static front. Rising temperatures in March and the completion of issue of the new insulated rubber combat boot contributed to the marked drop in incidence in that month. Further temperature correlations with daily incidence will be discussed in the subsection on "Physical Environment".

D. Weekly Incidence

Weekly incidence rates reflected prevailing low temperatures or sudden drops in temperature and presence of units in frontline positions (Appendix Table 2).

E. Occupational Selectivity

It has been shown (6) that cold injury is a disease of front-

line riflemen and may correctly be classed as occupational trauma. This concept is readily acceptable when considering the immobility of troops under enemy barrage. It is the front-line rifleman who is pinned down by enemy attack and especially so on active defense. It was interesting to observe whether conditions of static defense also would concentrate such injuries among front-line elements. Analysis of the vital data for 708 of the 716 cases is presented in Table 5. It will be noted that, whereas divisions made up 47% of the strength of the Eighth Army, 92% of the cases were in divisions; regiments represented but 28% of the army strength yet claimed 81% of the cases; and battalions, with but 20% of the strength of the army, suffered 76% of the cold injuries. An approximate ratio of 1:2:3:4 was noted among army, divisions, regiments and battalions respectively. With the division as the echelon of reference the ratio was 1:1.5: for division, regiment and battalion respectively. With the regiment as the echelon of reference the ratio was 1:1.3 for regiment and battalion, once more emphasizing the front-line locale of cold injury even in static defense.

F. Unit Attack Rates

Many factors have been implicated as contributing to or modifying cold injury. The number of combinations of these factors operating towards an increase or a reduction of cold injury incidence in any given unit is formidable. Since individual units experienced relatively low incidence on a

weekly or monthly basis in the 1951-52 experience in Korea, subsequent analyses of factors are for the Eighth Army as a whole. There is presented a cursory description of differences among the several divisions and regiments in Table 6. Though alluded to wherever pertinent in this section, the role of combat activity will be discussed in greater detail below. In Table 6 the total period rate reflects the absolute case incidence for the individual divisions. The mean monthly rate corrects for total time of the unit in Korea i.e. adjusts for those divisions present for but a fraction of the 5 month period.

Referring to the total period rates it will be noted that the 7th Infantry Division experienced the highest rate of frostbite among United States divisions. The role of combat intensity, clothing and weather (in relation to the 17th Regiment of this division) as contributory to this incidence, has been mentioned above. This incidence was primarily incurred in November and definitely influenced the total period and mean monthly rates of the division. The 45th Infantry Division had the second highest 5-month period rate. Moderate-scale company attacks with reconnaissance company support in January, as well as tank raids in February, contributed in no small way to excess frostbite in this division. The 3rd Infantry Division with the third highest rate suffered most of its cold injuries in November and principally in two regiments, the 7th and 65th. The former found itself in a

RESTRICTED
Security Information

TABLE 6
MONTHLY FROSTBITE RATES (per 1000 per annum)
FOR DIVISIONS, REGIMENTS AND SUPPORT ELEMENTS
UNITED STATES EIGHTH ARMY, KOREA, 1951-52

UNIT	Total Period Rate per 1000	Mean Monthly Rate/1000	Nov.	Dec.	Jan.	Feb.	March
1st Cav. Div.	0.5	6.4	6.4	-	-	-	-
5th Reg.			13.1				
7th Reg.			6.7				
8th Reg.			11.1				
Support							
1st Mar. Div.	0.3	0.9	1.3	0.4	2.5	0	0
1st Reg.							
5th Reg.							
7th Reg.							
Support							
2nd Inf. Div.	1.2	2.8	1.9	2.0	6.2	2.1	0.7
9th Reg.			3.7	3.5	2.7	3.7	
23rd Reg.						7.8	3.6
38th Reg.			3.5	3.5	21.5		
Support			1.3	1.5	4.3		
3rd Inf. Div.	4.9	12.0	44.8	6.9	6.8	2.6	0
7th Reg.			142.5	9.8	10.7		
15th Reg.			56.0	6.7		10.6	
65th Reg.			112.4	14.0	19.7		
Support			1.1	2.9	2.4	1.6	
7th Inf. Div.	10.5	25.7	81.0	10.3	14.7	24.7	0.7
17th Reg.			363.5	35.9	11.0	20.9	
31st Reg.			13.8	3.4	25.9	18.7	
32nd Reg.			7.6	6.8	26.8	79.7	3.6
Support			3.1	1.7	2.9	1.8	
24th Inf. Div	4.3	16.2	10.7	11.5	24.5	15.9	-
5th Reg.			19.8	30.7	35.8	34.5	
19th Reg.			12.6	11.8	6.3		
21st Reg.			30.8	19.6	35.0		
Support			1.2	2.5	4.7	13.6	
25th Inf. Div	2.4	5.7	5.5	4.7	3.7	13.8	1.4
14th Reg.				3.5	8.7	6.1	
27th Reg.			3.2				
35th Reg.			13.8	13.0	5.7	56.1	7.2
Support			7.6	3.4	2.4	3.4	
40th Inf. Div	4.7	33.8	-	-	61.5	33.1	0
160th Reg.					57.9	54.3	
223rd Reg.					148.6	75.1	
224th Reg.					-	25.1	
Support					10.0	5.1	
45th Inf. Div	6.5	16.2	0.7	5.9	32.2	29.4	1.4
179th Reg.			3.2	13.0	57.9	16.9	3.4
180th Reg.				15.0	89.4	47.4	
279th Reg.					23.5	30.3	
Support					10.9	26.0	1.7
Misc. 8th Army Units	0.5	0.9	0.3	0.6	1.7	1.4	0
TOTAL	3.0	6.8	12.2	3.6	8.3	9.4	0.3

RESTRICTED
Security Information

situation identical to that of the 17th Regiment, whereas the latter was the Puerto Rican regiment. The next highest rate was represented by the 40th Infantry Division whose initial elements in January experienced cold injury immediately upon regimental interchange. The 24th Division revealed monthly rates which showed trends in direct relation to the monthly temperatures, whereas the low 25th Division rate reflected its reserve status (except for one regiment) for a great portion of the winter. Contributing to the low incidence of frostbite in this regiment was the application of weather predictions in planning patrols and clothing of troops. The 2nd Infantry Division had an enviable record to which an awareness of cold injury, early issue of the insulated rubber boot and reserve status (in the first period of low temperatures) undoubtedly contributed. The 1st Cavalry's low rate may readily be attributed to its removal from the theater shortly after the first cold weather when it had but one regiment in the line. The best experience was registered by the 1st Marine Division which actually held colder positions on the line. This division was equipped with the new insulated boot before the first drop in temperature, which undoubtedly greatly influenced the incidence.

In general the mean monthly rates showed a high positive rank-order correlation (rho = +0.830) with the total period rates. The calculation of the mean monthly rates however changed the order of rank of the divisions from the order in

which their absolute incidence occurred. An examination of Table 6 reveals the 40th Infantry Division with the highest mean monthly rate (but fifth in absolute incidence). The 24th Infantry Division had a mean rate equal to that for the 45th Division (which was second in absolute incidence) and greater than that for the 3rd Division (which was third in absolute incidence). It is obvious that the cause for these apparent discrepancies lies in the absence of the diluting effect of lower general incidence rates in December upon the 40th Division and a similar lack of effect of March rates upon the 24th Division when these divisions were not in the theater. Thus, calculating the mean monthly rate for the 5-month period may correct for the actual duration of exposure, but does not take into consideration the varying weather and combat conditions month by month.

G. Degree and Site of Injury

Table 7 presents the distribution of the 716 United States cases of frostbite by degree and site of injury. As might be expected from the interaction between an agent of varying intensity and a host of varying or modifiable vulnerability, mild (first and second degree) injury constituted the majority of the case load. This inverse relationship between numbers and severity was most marked in the foot cases, but second degree injury was more prominent than first degree in the hand cases. A possible explanation is that even a mild first degree case of frostbite of the feet without (by definition)

vesiculation is painful enough upon further traumatization (such as standing and especially walking) to present himself for medical care, whereas a first degree hand case may exhibit temporization because of less discomfort and less opportunity for further trauma.

TABLE 7

DISTRIBUTION OF 716 CASES OF FROSTBITE
ACCORDING TO SITE AND DEGREE OF INJURY

Degree Of Injury	Number of Cases - Site of Injury: Total	Feet Alone	Hands Alone	Feet and Hands: Maximum Injury Feet*	Feet and Hands: Maximum Injury Hands	Ears Or Nose
First	275	219	29	21	0	6
Second	261	153	60	24	11	13
Third	143	118	9	13	3	0
Fourth	33	19	6	8	0	0
Indeterminate	4	4	-	-	-	-
Total No.	716	513	104	66	14	19
First	38.4%	42.7%	27.9%	31.8%	-	31.6%
Second	36.5%	29.8%	57.7%	36.4%	78.6%	68.4%
Third	20.0%	23.0%	8.7%	19.7%	21.4%	-
Fourth	4.6%	3.7%	5.8%	12.1%	-	-
Indeterminate	0.6%	0.8%	-	-	-	-
Total %	100.0%	100.0%	100.1%	100.0%	100.0%	100.0%

* Feet given preference when degree was identical

The bulk of the cases represented injuries to the feet alone (71.6%) and the greater number of combined hand and foot cases showed maximum injury to the feet (82.5% of the combined group). This distribution was what one would expect, for the hands may be moved more frequently in situ-

ations which restrict body and foot movement, they may be kept warm by body heat more readily (placing inside of field jacket), they are not dependent with resulting vascular stasis, they are not as often constricted by tight gear and, as will be discussed below, they are less frequently wet with sweat and external water than are feet.

The specific extremities or members involved are presented in Table 8. Both feet were involved in the majority of cases with hand and foot combinations next most frequently. With the exception of 18 ear cases and one nose case no other parts of the body were involved in this experience.

TABLE 8

DISTRIBUTION OF 712 CASES OF FROSTBITE
ACCORDING TO SITE OF INJURY
KOREA, 1951-52

Site of Injury	No.	%
One Hand	32	4.5
One Foot	63	8.8
Both Hands	70	9.8
Both Feet	445	62.5
One Hand and One Foot	3	0.4
Two Hands and Two Feet	59	8.3
One Hand and Two Feet	16	2.2
One Foot and Two Hands	5	0.7
One Ear	13	1.8
Two Ears	5	0.7
Nose	1	0.1
Total	712	99.8

On the hypothesis that cases subjected to more severe exposure and/or representing greater susceptibility or vulnerability because of other modifying factors, should not only

RESTRICTED
Security Information

have more severe injuries but also a greater part involvement, the data were analyzed (Table 9) for degree and parts involved. In 691 cases a significant difference between fourth and lesser degrees was noted when "both feet plus both hands" as well as "one hand plus one foot" were involved. However, because expected values were so small, the reliability of these components of the chi square was low and only a tendency may be said to exist.

TABLE 9

DISTRIBUTION OF 691 CASES OF FROSTBITE
ACCORDING TO SITE AND DEGREE OF INJURY
KOREA, 1951-52

Site of Injury	Degree of Injury								Total	
	First		Second		Third		Fourth			
	No.	%	No.	%	No.	%	No.	%	No.	%
One Hand	8	2.8	19	8.1	2	1.4	3	9.1	32	4.6
Both Hands	20	7.1	40	16.9	7	[illegible]	3	9.1	70	10.1
One Hand plus One Foot	1	0.4	1	0.4	0	-	1	3.0	3	0.4
One Foot	18	6.4	25	10.6	20	14.3	0	-	63	9.1
Both Feet	201	71.3	128	54.2	98	70.1	18	54.5	445	64.4
Both Feet plus One Hand	9	3.2	4	1.7	2	1.4	1	3.0	16	2.3
Both Hands plus One Foot	2	0.7	3	1.3	0	-	0	-	5	0.7
Both Feet plus Both Hands	23	8.2	16	6.8	11	7.9	7	21.2	57	8.3
Total	282	100.1	236	100.0	140	100.1	33	99.9	691	99.9

Chi square = 67.047 df = 21 P <.001

Figure 2 presents the monthly distribution of cases by degree and general site of injury. Attention is drawn to the

RESTRICTED
Security Information

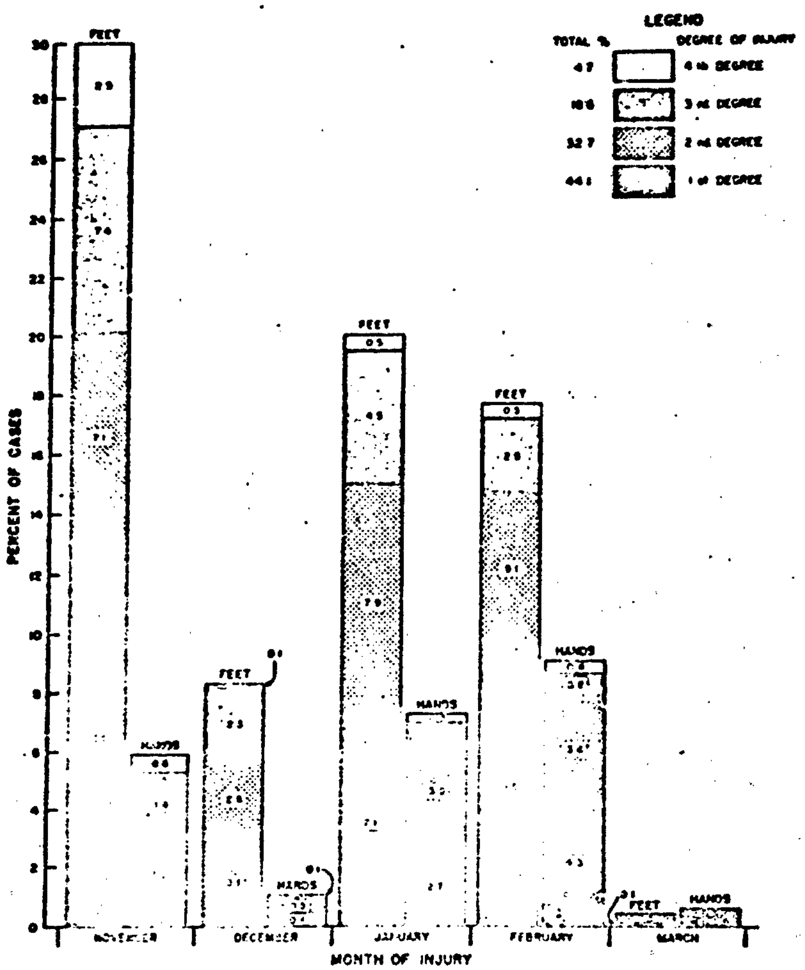


FIG. 2. MONTHLY INCIDENCE OF FROSTBITE ACCORDING TO SITE AND DEGREE OF INJURY, 8th U.S. ARMY, KOREA, 1951-52.

RESTRICTED
Security Information

increasing ratio of hand to foot cases as the winter progressed as well as to the decreasing trend in injuries of more severe degree. The relationship of the issue of the new insulated rubber boot to this phenomenon is discussed below but may not be the sole factor in the trend of milder injuries. General awareness of the problem, "acclimatization" as claimed by Blair and Dimitroff (8), and emphasis on prevention by the presence of the Cold Injury Research Team may have contributed to this trend.

H. Hour of Onset of Injury

The determination of onset of injury in frostbite is by no means a simple procedure. The exact time of onset of tissue damage may be controversial but certain subjective symptoms such as onset of numbness may be relied upon for an approximation of time of injury. Utilizing numbness as the criterion for onset, 681 cases of frostbite for whom data were available were distributed according to hour of onset of numbness (Table 10). It will be noted that the hourly incidence was lowest in the afternoon, mounted through the evening and night hours and reached a peak during the interval 0900 to 1200 hours. This obviously was a reflection of the relatively warmer afternoon temperatures, with an increase in incidence as the temperatures fell during the evening and night and the minimum temperature was reached at approximately 0600 hours. Coupled with this daily cycle of temperature was the characteristic tactical procedure in static defense of night and early morning

patrols as well as early morning attacks by the enemy with resultant frequent immobilization.

A comparison of the hour of onset of numbness established for the cases with that claimed by 420 bunker-mate controls as the time such cases complained of numbness is presented in Table 10. At best this comparison is but an indication of the reliability of the patient data and serves as a corroborative device.

TABLE 10

DISTRIBUTION OF 681 FROSTBITE CASES AND 420 BUNKER-MATE CONTROLS ACCORDING TO THE HOUR OF ONSET OF NUMBNESS AMONG THE CASES KOREA, 1951-52

Hour of Numbness	Cases		Controls*	
	No.	%	No.	%
0000 - 0259	93	13.7	73	17.4
0300 - 0559	108	15.9	71	16.9
0600 - 0859	118	17.3	78	18.6
0900 - 1159	128	18.8	63	15.0
1200 - 1459	55	8.1	30	7.1
1500 - 1759	40	5.9	21	5.0
1800 - 2059	60	8.8	26	6.2
2100 - 2359	79	11.6	58	13.8
Total	681	100.1	420	100.0
Chi square = 8.986 df = 7 P >.20				

* Controls claimed the designated interval to be the time of complaint of numbness by the cases.

VII. AGENT FACTORS

Although low temperature as the agent factor in cold injury will be more fully discussed below in the subsection on "Physical Environment" it is pertinent to emphasize here that cold is the

specific agent or immediate cause of frostbite. Cold or, more aptly, loss of body heat is the exciting cause of all cold injury whether it be immersion foot, trenchfoot or frostbite. In trenchfoot higher temperatures are involved for wetness is the synergistic factor (6) which hastens heat loss by its conducting quality. In frostbite wetness may play little or no role in the injury. The excessive dry cold in itself is conducive to rapid loss of body heat. Figure 3 illustrates the increases of case incidence for the entire Korean front with drops in temperature. This was even more dramatically observed in the winter of 1950-51 (7) but was complicated by enemy attack as well. In the winter of 1951-52 a static front permitted the demonstration of more uniform temperature effects even though total incidence was low.

Precipitation played little or no role in the Korean experience for with the onset of winter at the end of November and early December the ground froze quickly and no significant thaw ensued until spring. The rainy season occurs in midsummer. Trenchfoot was not observed in either 1950-51 or 1951-52.

Frostbite was the type of cold injury seen in Korea and was basically due to relatively shorter exposures to more intense cold than in trenchfoot, notwithstanding the significant role played by the several modifying factors to be described.

VIII. ENVIRONMENTAL FACTORS

A. Weather - General

For the first time in cold injury field research under combat conditions, finite temperatures and wind speeds were

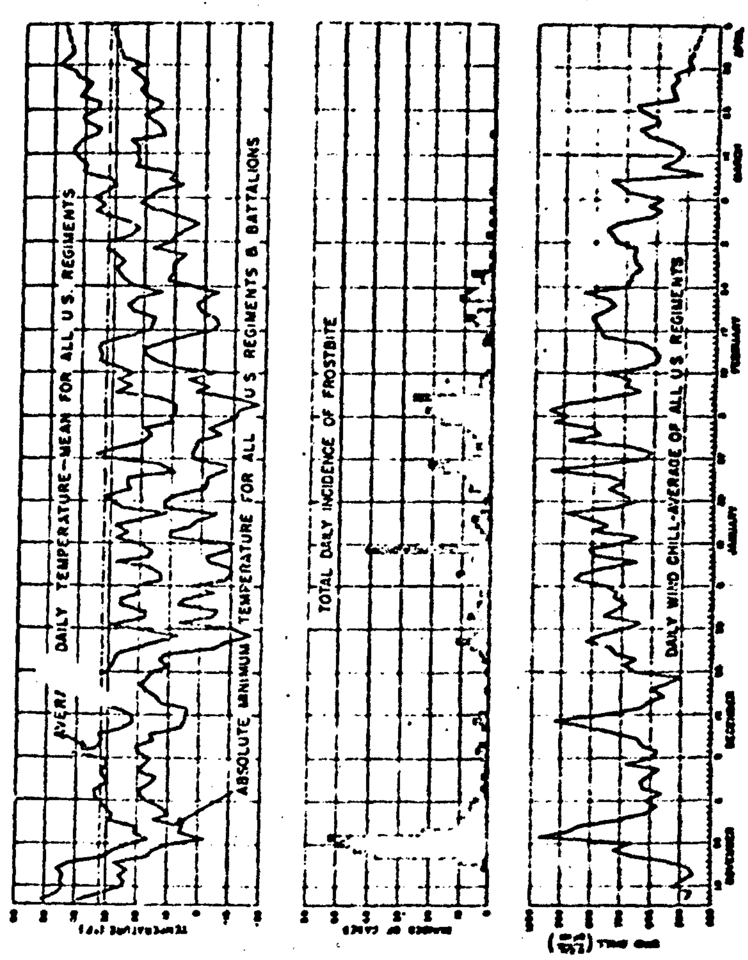


FIGURE 3. DAILY INCIDENCE OF FROSTBITE AND SELECTED WEATHER DATA FOR THE U.S.-KOREAN FRONT FOR 1951-52

measured along the front lines. These data gave a much more accurate picture of the actual conditions of exposure than ever before. As described in detail in another section of this report (Section I) weather data for regiments and battalions were available for correlations with incidence and for other analyses. Specific map coordinates were charted for the location of cases and controls at time of frostbite so that the data of the nearest battalion weather station could be applied.

B. Weather and Incidence of Frostbite

Since cold injury is a function of loss of body heat, it is obvious that many modifying factors, increasing or diminishing such loss, will interfere with a simple direct relationship between incidence, temperature and length of exposure. An inspection of Figure 3, however, seems to indicate that possibly significant correlations exist between incidence of frostbite and mean daily average temperatures, mean daily minimum temperatures and average windchill for the front as a whole. Utilizing the data for these variables from Appendix Table 1, scatter diagrams (e.g. Fig. 4) were constructed and coefficients of correlation and regression line equations calculated. Linearity of the relationship was assumed. Considering all the data irrespective of differences in combat activity throughout the 5-month period, significant coefficients of correlation by the product-moment method were elicited for daily average temperature, daily minimum temper-

ature and daily average windchill (Table 11). The standard errors of estimate (S_y) revealed rather large disperions, however, and the predictive efficiencies (% Eff.) of the regression equations were quite low. Inspection of the individually plotted points for each scatter diagram revealed five points which deviated markedly from linearity. The original data disclosed these to represent the first 5 days of the cold period when intense regiment-sized enemy attacks occurred. Thus the activity of these 5 days differed considerably from the static defense type of activity which involved patrolling and line holding during the balance of the winter. Exclusion of these five values in the correlations with daily average temperatures (Fig. 5), daily minimum temperatures (Fig. 6)* and daily average windchill (Fig. 7) not only increased the r values but enhanced the predictive efficiencies considerably (Table 12). Thus the coefficients for average temperature, minimum temperature and average windchill are all reasonably good predictors when the type of activity is fairly uniform. It may be said that the regression equations as calculated are applicable to a situation of static defense provided that all other significant factors which existed in Korea 1951-52 are reasonably simulated.

* Since a constant of 20° was added to eliminate all negative temperature values in calculating the product-moment correlation with minimum temperature, this constant must be added to the X value in using the regression equations.

TABLE 11

PRODUCT-MOMENT CORRELATIONS BETWEEN DAILY INCIDENCE AND SELECTED WEATHER DATA, IRRESPECTIVE OF COMBAT ACTIVITY
KOREA, 1951-52

Weather Item	r	S_y	Regression Equation*	% Eff. 100(1-k)	t	P	1% Fiducial Limits of r
Daily Avg. Temp.	-0.421	±8.76	Y_c = 18.7396 -0.4896X	9.29	4.930	<.001	-0.217 to -0.592
Daily Min. Temp.	-0.325	±9.15	Y_c = 14.0135 -0.3061X	5.41	3.724	<.001	-0.107 to -0.510
Daily Avg. Windchill	+0.431	±8.72	Y_c = -21.5324 +0.3914X	9.75	5.039	<.001	+0.227 to +0.599

* Y_c = expected number of cases, X = Temperature

RESTRICTED
Security Information

TABLE 12

PRODUCT-MOMENT CORRELATIONS BETWEEN DAILY INCIDENCE AND SELECTED WEATHER DATA, EXCLUSIVE OF DATA FOR 22 NOV. TO 26 NOV. INCLUSIVE KOREA, 1951-52

Weather Item	r	S_y	Regression Equations*	% Eff. 100(1-k)	t	p	1% Fiducial Limits of r
Daily Avg. Temp.	-0.627	±4.90	Y_c = 16.9558 -0.4767X	22.04	7.933	<.001	-0.462 to -0.753
Daily Min. Temp.	-0.594	±5.06	Y_c = 14.1440 -0.3681X	19.54	7.290	<.001	-0.410 to -0.725
Daily Avg. Windchill	+0.568	±5.18	Y_c = -19.4490 +0.3419X	17.67	6.968	<.001	+0.390 to +0.710

* Y_c = expected number of cases, X = Temperature

RESTRICTED
Security Information

RESTRICTED
Security Information

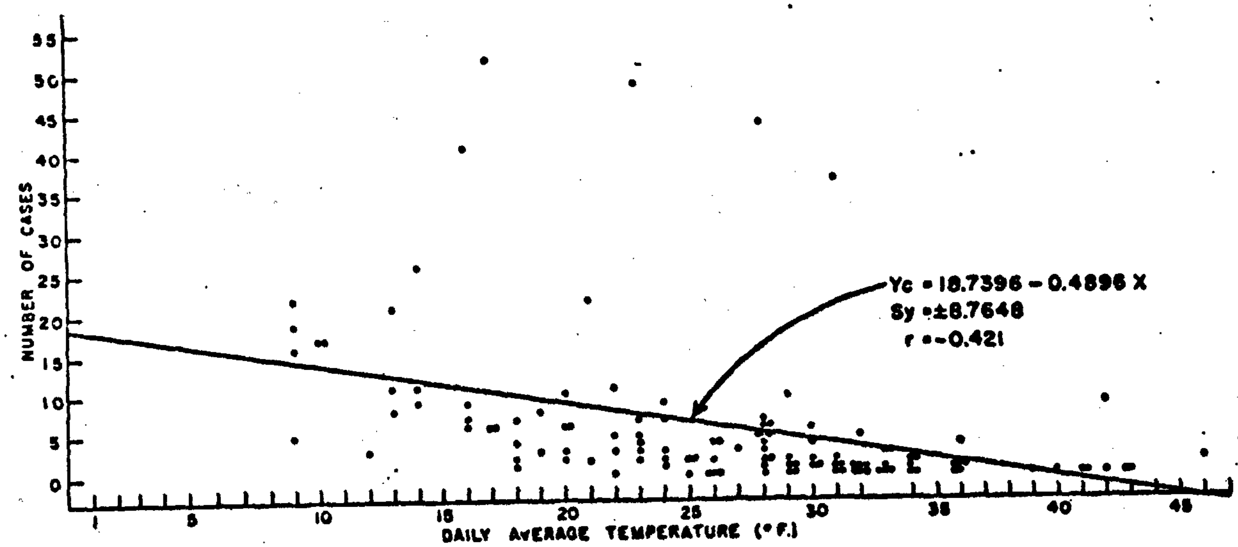


FIG. 4. RELATIONSHIP BETWEEN DAILY INCIDENCE OF COLD INJURY AND DAILY AVERAGE TEMPERATURE - ENTIRE U.S. FRONT - KOREA - 1951-52.

RESTRICTED
Security Information

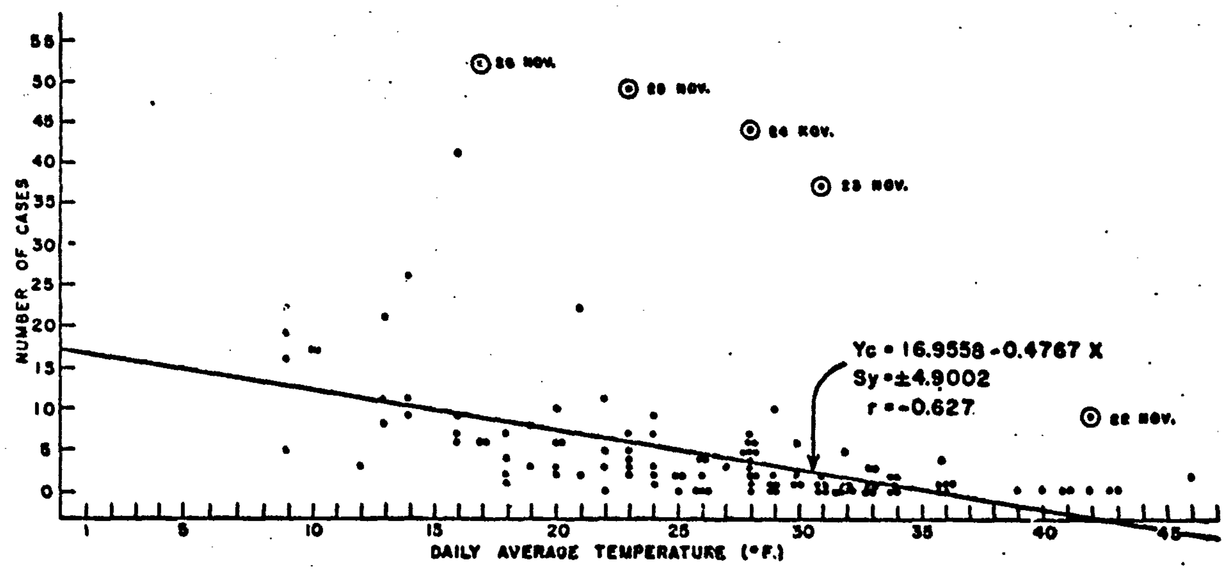


FIG. 5. RELATIONSHIP BETWEEN DAILY INCIDENCE OF COLD INJURY AND DAILY AVERAGE TEMPERATURE — ENTIRE U.S. FRONT — KOREA — 1951—52 (LESS DATA FOR 22-26 NOV., 1951, INCLUSIVE).

RESTRICTED
Security Information

RESTRICTED
Security Information

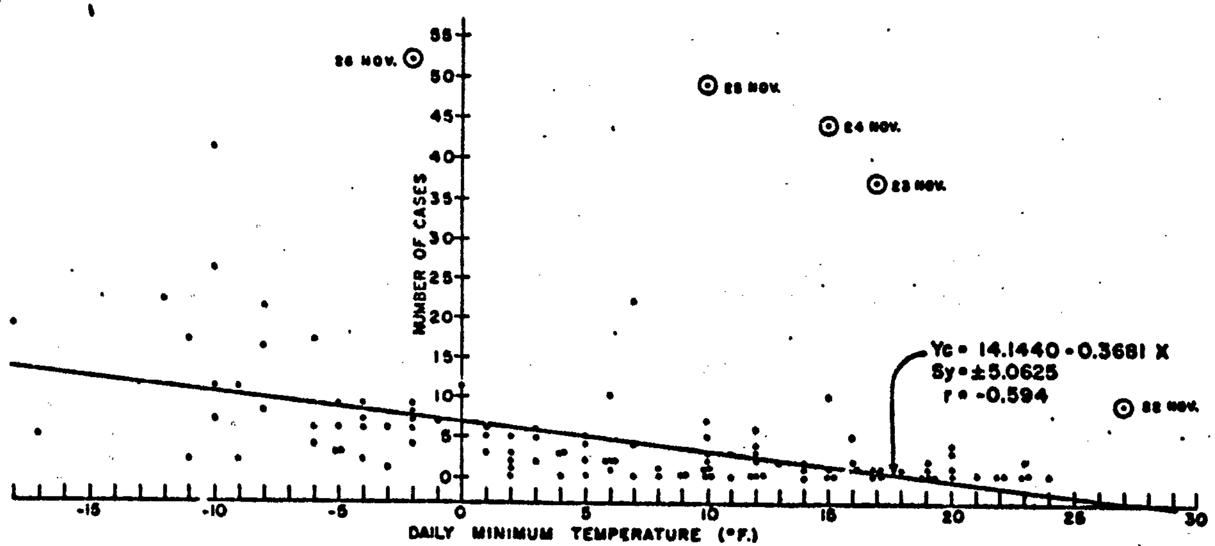


FIG. 6. RELATIONSHIP BETWEEN DAILY INCIDENCE OF COLD INJURY AND MINIMUM DAILY TEMPERATURE — ENTIRE U.S. FRONT—KOREA—1951—52 (LESS DATA FOR 22-26 NOV., 1951, INCLUSIVE).

RESTRICTED
Security Information

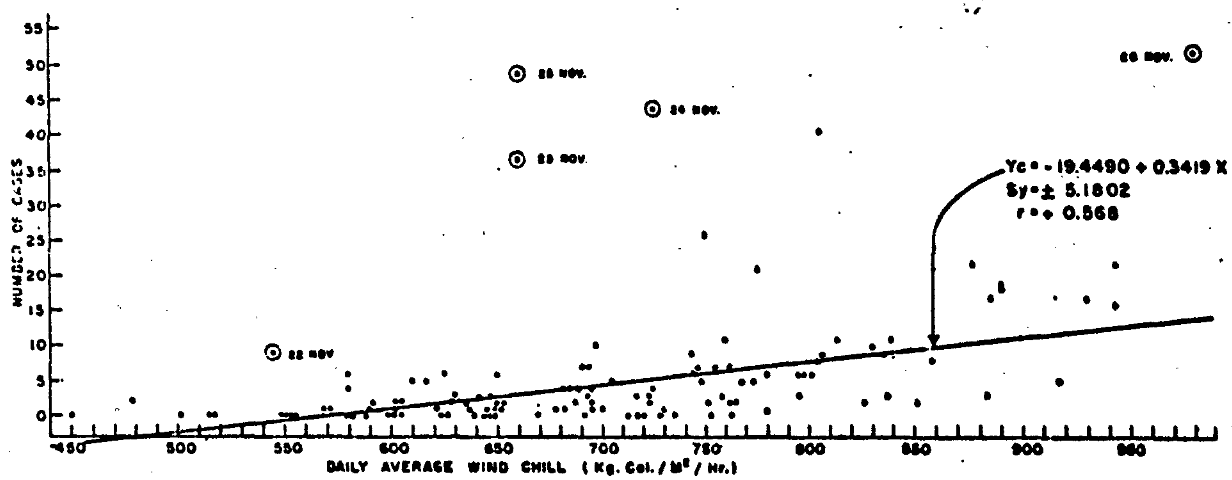


FIG. 7. RELATIONSHIP BETWEEN DAILY INCIDENCE OF COLD INJURY AND DAILY AVERAGE WIND CHILL ENTIRE U.S. FRONT – KOREA – 1951 – 52 (LESS DATA FOR 22-26 NOV., 1951, INCLUSIVE).

RESTRICTED
Security Information

Attention must be drawn to the fact that spurious recommendations may be derived from these findings unless it is recalled that daily average temperature and windchill are retrospective data whereas the next day's minimum temperature can be forecast with reasonable accuracy on the basis of the evening dew point. Utilizing the regression equation for daily minimum temperature it was noted that each decrement of 10 degrees (F.) in temperature (below 18.4° F.) was productive of an increment of 3.7 cases of frostbite. The daily minimum temperature level above which no cases would be expected to occur was found to be 18.4° F. Reinspection of the daily incidence (exclusive of the intense combat period 22-26 November) revealed that only 11 cases in 516 or 2.1% occurred at temperatures above the 18.4° F. level (Appendix Table 1).

Utilizing the equation for average temperature it is interesting to speculate on what the incidence of frostbite would have been in December 1951-52 had the temperatures for December 1950-51 prevailed, but under conditions of static defense (December temperatures in 1950-51 were 20 degrees (F.) lower). Daily temperatures for December 1951-52 were adjusted for this difference and calculations yielded a total of 385 cases, 542% greater than actually occurred. This number is nevertheless much smaller than the number of cases which actually occurred in December 1950-51. To this latter incidence, such factors as heavy combat in a retrograde

movement and lack of adequate gear presumably contributed.

The incidence of the period 22-26 November 1952, excluded because of heavy combat, was correlated with daily average temperatures. A significant product-moment coefficient of correlation of -0.955 was obtained, but because of the smallness of sample size the 1% confidence limits of this coefficient ranged from -0.111 to -0.999. Thus a correlation of incidence with temperature does exist under conditions of intense combat. The trend of values and the possible regression equations derivable from such data leads to the belief that further experience with this type of measurement can provide equations for any situation with various combinations of factors. Had front-line temperature data by units been available in 1950-51, equations of incidence-temperature relationships under conditions of heavy combat might have been derived for a much larger experience.

Since regimental differences in temperature for any given day were noted (see Section I), it was of interest to determine to what extent these differences operated in producing varying incidence rates among the regiments. Data for this type of inquiry were sparse, for the instances in which outbreaks of injury occurred in sufficient size to involve a great enough number of regiments for correlation were few. The period 2-6 February 1952 inclusive was selected for this type of correlation between case incidence and regimental temperatures (Table 13). The product-moment

coefficient of correlation for minimum temperature (Fig. 8) was found to be -0.6877. Though significantly different from zero and indicating that a correlation exists, the reliability of the coefficient was small as evidenced by the 1% confidence limits of -0.03 to -0.94.

TABLE 13

COMPARISON OF PERIOD CASE RATES OF FROSTBITE AND REGIMENTAL TEMPERATURE FOR THE PERIOD 2 - 6 FEBRUARY 1952 INCLUSIVE

Regiment	No. of Cases	Period Rate/1000	Avg. Temp. °F.	Min. Temp. °F.
23rd	2	0.6	2.0	- 3.0
15th	1	0.3	10.4	- 5.0
17th	5	1.3	22.7	- 6.0
31st	6	1.4	10.8	-10.0
32nd	10	2.7	9.8	-12.0
5th	7	2.1	7.8	- 5.0
160th	10	2.3	7.2	-9.0
223rd	13	3.8	6.8	-10.0
224th	3	1.2	No Data	No Data
179th	3	0.8	8.0	- 2.0
180th	10	2.6	12.6	- 6.0
279th	5	1.3	10.0	- 5.0

Table 14 presents a comparison of minimum temperatures of exposure for cases and controls. It will be noted that the mean minimum temperature of exposure for cases was 10.9° F. The statistically significant but practically minor difference in mean temperatures between cases and controls can be readily explained. For cases, the minimum temperatures were charted for the period represented by the hour of onset of numbness as the mid-point. For controls, the minimum temperature for the entire period of exposure from onset of exposure (for the case) to time of rewarming was used. The average

RESTRICTED
Security Information

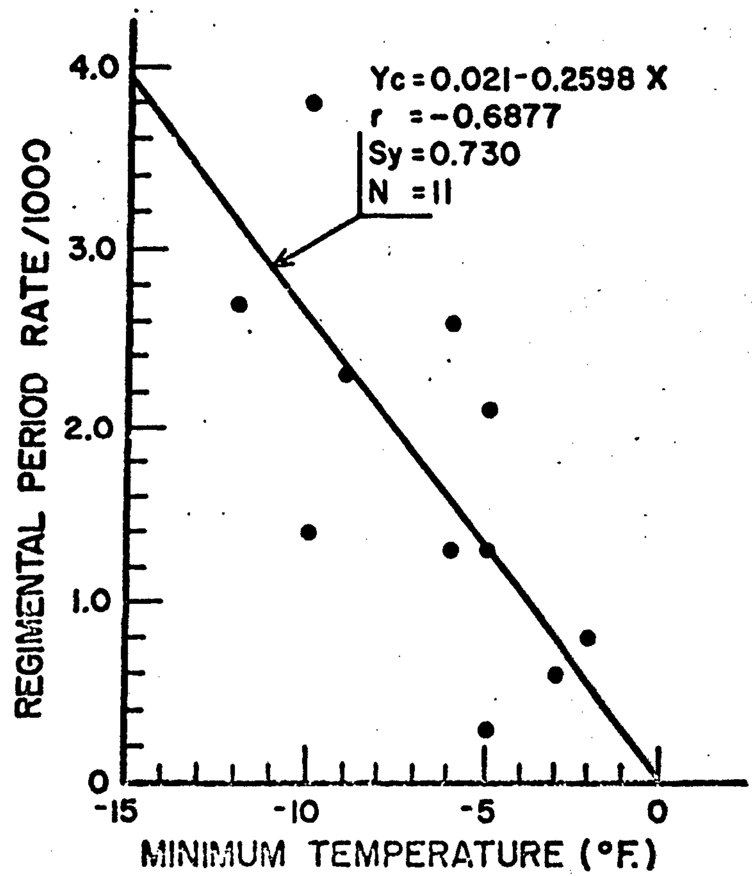


FIG. 8. CORRELATION OF REGIMENTAL CASE INCIDENCE RATES AND REGIMENTAL MINIMUM TEMPERATURES. 2-6 FEB. 1952, INC.

RESTRICTED
Security Information

temperature of the period of total exposure (not to be confused with the average temperature of the entire day) was thus considered more reliable for comparative purposes between cases and controls. No significant difference in average temperature of exposure was noted between cases and controls (Table 15).

TABLE 14

COMPARISON OF 643 CASES OF FROSTBITE AND 442 BUNKER-MATE CONTROLS WITH RESPECT TO MINIMUM TEMPERATURE OF EXPOSURE KOREA, 1951-52

Minimum Temp. of Exposure	Cases No.	Cases %	Controls No.	Controls %
> 37° F.	4	0.6	1	0.2
31 to 37° F.	20	3.1	15	3.4
24 to 30° F.	102	15.9	82	18.6
17 to 23° F.	135	21.0	98	22.2
10 to 16° F.	126	19.6	76	17.2
3 to 9° F.	110	17.1	48	10.9
-4 to 2° F.	112	17.4	90	20.4
-11 to -5° F.	34	5.3	32	7.2
-18 to -12° F.	0	0	0	0
-25 to -19° F.	0	0	0	0
< -25° F.	0	0	0	0
Totals	643	100.0	442	100.1
Means	10.9°		12.7°	
S. D.	±12.17		±11.82	
t = 2.513			P <0.02	

TABLE 15

COMPARISON OF 645 CASES OF FROSTBITE AND 443 BUNKER-MATE CONTROLS WITH RESPECT TO AVERAGE TEMPERATURE OF EXPOSURE KOREA, 1951-52

Average Temp. of Exposure	Cases		Controls	
	No.	%	No.	%
> 37° F.	7	1.1	1	0.2
31 to 37° F.	52	8.1	50	11.3
24 to 30° F.	143	22.2	92	20.8
17 to 23° F.	147	22.8	113	25.5
10 to 16° F.	142	22.0	70	15.8
3 to 9° F.	94	14.6	70	15.8
-4 to 2° F.	53	8.2	40	9.0
-11 to -5° F.	7	1.1	7	1.6
-18 to -12° F.	0	0	0	0
Totals	645	100.1	443	100.0
Means	17.0°		17.4°	
S. D.	±10.16		±10.80	
t = 0.5058		P > 0.6		

It will be seen from Table 14 that the modal minimum temperature of exposure for both cases and controls is in the interval 17° - 23° F. and that the incidence falls off with still lower temperatures. This is not paradoxical when it is noted that this merely reflects fewer days of lower temperature. The role of temperature during exposure on incidence of frostbite may be further elicited by studying the rates of injury at various temperature levels on the basis of man-days of exposure. This has

been calculated for regiments in reserve and in the line for the period 1 December 1951 to 17 March 1952 (Table 16). Total man-days of exposure at a given temperature were calculated for the individual temperature levels by summating the products of the average monthly strengths of the respective regiments and days of exposure at that specific daily average temperature. Regiment-days of exposure is merely an index to the number of units in the line or in reserve for the number of days at that particular temperature of exposure. From Table 16 it can be seen that the apparent paradox of diminishing incidence with lower temperatures is resolved and a definite inverse relationship is established. As the daily average temperatures decreased, the incidence rates, expressed as cases per 100,000 man-days of exposure, increased. This was true for regiments both in the line and in reserve. A comparison of line and reserve troop rates revealed an average of 4.9 cases per 100,000 man-days of exposure for the former and 2.3 cases per 100,000 man-days exposure for the latter or an approximate ratio of 2:1. This relationship as well as that with respect to active defense will be discussed below under "Combat Action".

The average windchill (Kg.cal/M^2/Hr. heat loss) during exposure was derived from regimental data on wind speed and temperature and applied to each case and control. Table 17 reveals that there was virtually no difference in the mean average windchill during exposure for the two groups. Of

RESTRICTED
Security Information

TABLE 16

COMPARISON OF REGIMENTAL LINE AND RESERVE FROSTBITE RATES IN CASES PER 100,000 MAN-DAYS OF EXPOSURE AT THE SEVERAL LEVELS OF DAILY AVERAGE TEMPERATURES
KOREA, 1 DEC. 1951 TO 17 MARCH 1952

Daily Average Temperature in ° F.	Line Troops				Reserve Troops			
	Reg. Days	Man-Days of Exposure	Cases	Cases Per 100,000 Man-Days Exposure	Reg. Days	Man-Days of Exposure	Cases	Cases Per 100,000 Man-Days Exposure
45° to 51°	13	48,842	0	-	7	25,777	0	-
38° to 44°	109	411,261	2	0.5	61	231,779	0	-
31° to 37°	316	1,189,479	17	1.4	191	738,657	4	0.5
24° to 30°	523	1,952,507	56	2.9	257	972,108	14	1.4
17° to 23°	307	1,141,145	45	3.9	132	501,338	19	3.8
10° to 16°	209	777,192	82	10.6	98	366,244	25	6.8
3° to 9°	37	323,329	85	26.3	9	30,872	4	13.0
Total	1,564	5,843,755	287	4.9	755	2,866,775	66	2.3

RESTRICTED
Security Information

TABLE 17

DISTRIBUTION OF 590 CASES OF FROSTBITE AND 419 BUNKER-MATE CONTROLS ACCORDING TO AVERAGE WINDCHILL DURING EXPOSURE KOREA, 1951-52

Average Windchill (Kg. cal/M^2/hr.)	Cases		Controls	
	No.	%	No.	%
< 700	101	17.1	83	19.8
700 - 824	278	47.1	185	44.1
825 - 949	149	25.2	104	24.8
950 - 1074	50	8.5	40	9.5
1075 - 1199	11	1.9	6	1.4
1200 - 1324	1	0.2	1	0.2
1325 - 1449	0	-	0	-
Total	590	100.0	419	99.8
Mean	799.8		799.0	
S. D.	± 118.53		± 119.48	
$t = 0.105$ $P > .90$				

interest is the fact that 50% of the cases occurred at windchills of 800 (cold) or less. This corresponds well with the fact that the highest daily average windchill for the front as a while experienced during the winter of 1951-52 was 975 Kg. cal/M^2/hr., a low borderline subarctic value.

C. Weather and Severity of Injury

It is reasonable to assume that the degree of injury in frostbite should be directly proportional to the intensity of cold or inversely to the temperature. That such a simple relationship is modified by many factors which diminish or

enhance heat loss has already been mentioned. However, the finding of significantly good correlations between minimum and average temperatures, windchill and incidence of frostbite led to the exploration of the possibility of a relatively simple relationship between temperature and degree of severity of frostbite. Thus the data on degree of injury for foot and hand cases were individually distributed according to minimum temperature (Tables 18 and 19), average temperature (Tables 20 and 21) and average windchill (Tables 22 and 23) during exposure.

TABLE 18

RELATION OF DEGREE OF INJURY TO MINIMUM TEMPERATURE OF EXPOSURE AMONG 514 CASES OF FROSTBITE OF THE FEET KOREA, 1951-52

Minimum Temp. of Exposure	Degree of Injury - Feet								Total	
	First		Second		Third		Fourth			
	No.	%	No.	%	No.	%	No.	%	No.	%
>37° F.	3	1.4	0	0.0	0	0.0	1	4.0	4	0.8
31 to 37° F.	7	3.3	3	1.8	9	7.9	0	0.0	19	3.7
24 to 30° F.	32	15.2	27	16.4	22	19.3	6	24.0	87	16.9
17 to 23° F.	61	29.0	24	14.5	25	21.9	5	20.0	115	22.4
10 to 16° F.	41	19.5	47	28.5	18	15.8	5	20.0	111	21.6
3 to 9° F.	34	16.2	22	13.3	16	14.0	5	20.0	77	15.0
-4 to 2° F.	25	11.9	32	19.4	20	17.5	3	12.0	80	15.6
-11 to -5° F.	7	3.3	10	6.1	4	3.5	0	0.0	21	4.1
Total	210	99.8	165	100.0	114	99.9	25	100.0	514	100.1
Mean	14.4°		11.8°		14.7°		14.7°		13.6°	
S. D.	± 10.22		± 10.82		± 11.71		± 9.95		± 10.81	

TABLE 19

RELATION OF DEGREE OF INJURY TO MINIMUM TEMPERATURE
OF EXPOSURE AMONG 111 HAND CASES OF FROSTBITE
KOREA, 1951-52

Minimum Temp. of Exposure	Degree of Injury - Hands								Total	
	First		Second		Third		Fourth			
	No.	%	No.	%	No.	%	No.	%	No.	%
>37° F.	0	-	0	-	0	-	0	-	0	-
31 to 37° F.	0	-	1	1.5	0	-	0	-	1	0.9
24 to 30° F.	7	25.0	7	10.4	0	-	0	-	14	12.6
17 to 23° F.	2	7.1	11	16.4	3	30.0	0	-	16	14.4
10 to 16° F.	4	14.3	7	10.4	0	-	1	16.7	12	10.8
3 to 9° F.	5	17.9	14	20.9	6	60.0	2	33.3	27	24.3
-4 to 2° F.	7	25.0	20	29.9	1	10.0	1	16.7	29	26.1
-11 to -5° F.	3	10.7	7	10.4	0	-	2	33.3	12	10.8
Total	28	100.0	67	99.9	10	100.0	6	100.0	111	99.9
Mean	10.0°		8.1°		9.5°		1.3°		8.3°	
S. D.	± 12.64		± 11.22		± 7.97		± 9.29		± 11.17	

No relation between minimum temperature, average temperature or average windchill and degree of injury of the feet or of the hands was apparent. In each comparison second degree injuries of the feet tended to show significantly lower mean temperatures and a higher windchill during exposure. It is felt, in view of lack of trends in mean temperatures in relation to degree of injury, that this solitary difference in second degree frostbite of the feet may be a chance finding. The repetition of this difference in average temperature and average windchill

TABLE 20

RELATION OF DEGREE OF INJURY TO AVERAGE TEMPERATURE OF EXPOSURE AMONG 516 CASES OF FROSTBITE OF THE FEET KOREA, 1951-52

Average Temp. of Exposure	Degree of Injury - Feet								Total	
	First		Second		Third		Fourth			
	No.	%	No.	%	No.	%	No.	%	No.	%
>37° F.	3	1.4	1	0.6	2	1.7	1	4.0	7	1.4
31 to 37° F.	13	6.2	8	4.8	22	19.0	3	12.0	45	8.9
24 to 30° F.	61	29.2	31	18.7	23	19.8	8	32.0	123	23.8
17 to 23° F.	52	24.9	48	28.9	23	19.8	2	8.0	125	24.2
10 to 16° F.	43	20.6	35	21.1	19	16.4	9	36.0	106	20.5
3 to 9° F.	25	12.0	24	14.5	17	14.7	2	8.0	68	13.2
-4 to 2° F.	12	5.7	16	9.6	7	6.0	0	0.0	35	6.8
-11 to -5° F.	0	0.0	3	1.8	3	2.6	0	0.0	6	1.2
Total	209	100.0	166	100.0	116	100.0	25	100.0	516	100.0
Mean	18.6°		15.9°		18.8°		20.3°		17.9°	
S. D.	± 9.19		± 9.90		± 11.47		± 9.06		± 10.05	

does not add significance to this item, since average temperatures of exposure are distinctly modified by minima and windchill is dependent upon temperature as well as wind speed.

It should be noted, however, that in every instance hand cases had distinctly lower mean temperatures of exposure and a higher mean windchill during exposure than did the feet cases. These differences were statistically significant and represented 5.3° F. for mean minimum temperatures ($P < .001$), 4.2° F. for mean average temperatures ($P < .001$) and 35.5 Kg. cal/M^2/hr. for mean average windchills ($P < .01$). These

RESTRICTED
Security Information

TABLE 21

RELATION OF DEGREE OF INJURY TO AVERAGE TEMPERATURE OF EXPOSURE AMONG 111 CASES OF FROSTBITE OF THE HANDS KOREA, 1951-52

Average Temp. of Exposure	Degree of Injury - Hands								Total	
	First		Second		Third		Fourth			
	No.	%	No.	%	No.	%	No.	%	No.	%
>37° F.	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
31 to 37° F.	2	7.1	4	6.0	0	0.0	0	0.0	6	5.4
24 to 30° F.	6	21.4	11	16.4	1	10.0	0	0.0	18	16.2
17 to 23° F.	4	14.3	8	11.9	3	30.0	2	33.3	17	15.3
10 to 16° F.	6	21.4	19	28.4	3	30.0	1	16.7	29	26.1
3 to 9° F.	6	21.4	13	19.4	2	20.0	2	33.3	23	20.7
-4 to 2° F.	4	14.3	12	17.9	1	10.0	0	0.0	17	15.3
-11 to -5° F.	0	0.0	0	0.0	0	0.0	1	16.7	1	0.9
Total	28	99.9	67	100.0	10	100.0	6	100.0	111	99.9
Mean	15.0°		13.5°		13.7°		9.5°		13.7°	
S. D.	± 11.12		± 10.43		± 8.83		± 11.63		± 10.33	

differences appeared logical in that movement of the hands, protection of them by placing them inside parkas, jackets or against the body and ease of warming over even small fires of sticks or canned heat are all much more readily accomplished than for the feet. Thus a lower temperature would be necessary to overcome these protective actions.

D. Duration of Exposure

The average duration of exposure for the cases of frostbite was 10.1 hours (Table 24). The controls showed no significant difference in exposure time. The calculation of duration of

RESTRICTED
Security Information

RESTRICTED
Security Information

TABLE 22

DISTRIBUTION OF 485 CASES OF FOOT FROSTBITE ACCORDING TO AVERAGE WINDCHILL DURING EXPOSURE KOREA, 1951-52

Avg. Windchill During Exposure (Kg. cal/M²/hr.)	Maximum Degree of Injury - Feet								Total	
	First		Second		Third		Fourth			
	No.	%	No.	%	No.	%	No.	%	No.	%
<700	43	20.9	16	10.1	27	27.8	7	29.2	93	19.2
700 - 824	102	49.5	77	48.7	38	39.2	9	37.5	226	46.6
825 - 949	41	19.9	50	31.6	23	23.7	5	20.8	119	24.5
950 - 1074	16	7.8	13	8.2	7	7.2	3	12.5	39	8.0
1075 - 1199	4	1.9	2	1.3	2	2.1	0	0.0	8	1.6
1200 - 1324	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Total	206	100.0	158	99.9	97	100.0	24	100.0	485	99.9
Mean	785.9		816.1		775.7		782.0		793.5	
S. D.	± 118.06		± 101.22		± 131.64		± 130.27		± 117.14	

exposure varied with the type of activity. For patrols the onset of exposure was arbitrarily taken as the time walking ceased, either because of arrival at the ambush point or because of pinning action of enemy fire. In guard situations this was obviously the beginning of posting guard; in vehicular incidents, the time of mounting; and in foxholes, the time immobilization by enemy fire or other cause began. Combinations of activities in some few instances occurred but in all cases exposure was deemed to have begun with relative immobilization from any cause and ended with the act of

RESTRICTED
Security Information

TABLE 23

DISTRIBUTION OF 105 CASES OF HAND FROSTBITE ACCORDING
TO AVERAGE WINDCHILL DURING EXPOSURE
KOREA, 1951-52

Avg. Windchill During Exposure	Maximum Degree of Injury - Hands								Total	
	First		Second		Third		Fourth			
(Kg. cal/M^2/hr.)	No.	%	No.	%	No.	%	No.	%	No.	%
<700	4	15.4	3	4.6	1	12.5	0	0.0	8	7.6
700 - 824	14	53.8	34	52.3	2	25.0	2	33.3	52	49.5
825 - 949	5	19.2	19	29.2	3	37.5	3	50.0	30	28.6
950 - 1074	2	7.7	6	9.2	2	25.0	1	16.7	11	10.5
1075 - 1199	1	3.8	2	3.1	0	0.0	0	0.0	3	2.9
1200 - 1324	0	0.0	1	1.5	0	0.0	0	0.0	1	1.0
Total	26	99.9	65	99.9	8	100.0	6	100.0	105	100.1
Mean	798.5		833.7		861.8		866.7		829.0	
S. D.	± 127.30		± 121.28		± 127.42		± 103.08		± 120.58	

rewarming. In special instances other considerations played a part, e.g. breaking through the ice on a patrol, when exposure time was calculated from this act even though walking to the ambush point continued.

Exposure times varied for different types of activity as can be noted in Table 25. Four hundred forty cases were grouped according to enemy contact and pinning action, transport and miscellaneous and, within each group, the specific activity or mission. These activities were verified by visits to the respective units during control interviewing. The longer mean

TABLE 24

DISTRIBUTION OF 683 CASES OF FROSTBITE AND 442 BUNKER-MATE CONTROLS ACCORDING TO DURATION OF EXPOSURE KOREA, 1951-52

Duration of Exposure (Hours)	Cases		Controls	
	No.	%	No.	%
0 - 4	257	37.6	155	34.3
4.1 - 8	173	25.3	126	27.9
8.1 - 12	107	15.7	78	17.3
12.1 - 16	48	7.0	38	8.4
16.1 - 20	10	1.5	8	1.8
20.1 - 24	30	4.4	15	3.3
2 Days	29	4.2	4	3.1
3 Days	12	1.8	6	1.3
>3 Days	17	2.5	12	2.6
Total	683	100.0	442	100.0
Mean	10.1 Hrs.		9.5 Hrs.	
S. D.	± 12.91		± 11.49	
t = 0.795 P >.40				

exposure times in this series occurred during enemy contact on the Main Line of Resistance, i.e. attack by the enemy, with or without pinning action, the posting of ground guards around gun emplacements in the line, tank missions and construction work. The shorter mean exposure times occurred during patrol activities when contact with the enemy was made. It is apparent from this comparison that the shorter mean exposure times are synonymous with those activities representing potentially greater immobilization. Thus one may infer that decreasing mobility tends to reduce the exposure

TABLE 25

MEAN EXPOSURE TIMES OF 440 CASES OF FROSTBITE ACCORDING TO THE SPECIFIC TYPE OF ACTIVITY IN WHICH THEY WERE ENGAGED
KOREA, 1951-52

Specific Type of Activity	No. of Cases	Mean Hours of Exposure	Standard Deviation	Mean Man-Hours of Exposure
A. Enemy Contact with Pinning Action - Total	107	9.0	± 11.53	963.0
1. Combat patrol	3[illegible]	6.5	± 2.96	208.0
2. Ambush patrol	0	-	-	-
3. Security patrol	6	7.3	± 4.53	43.8
4. Reconnaissance patrol	0	-	-	-
5. On M.L.R.	64	10.5	± 14.37	672.0
6. Outpost guard	5	8.4	± 9.27	42.0
B. Enemy Contact with No Pinning Action - Total	42	10.1	± 12.71	424.2
1. Combat patrol	20	5.8	± 2.48	116.0
2. Ambush patrol	2	6.0	-	12.0
3. Security patrol	1	6.0	-	6.0
4. Reconnaissance patrol	0	-	-	-
5. On M.L.R.	17	16.8	± 18.85	285.6
6. Outpost guard	2	2.0	-	4.0
C. No Enemy Contact - Total	209	9.4	± 12.57	1934.6
1. Combat patrol	15	7.6	± 3.05	114.0
2. Ambush patrol	40	7.3	± 7.86	290.0
3. Security patrol	20	6.8	± 4.13	136.0
4. Reconnaissance patrol	3	8.7	± 2.83	26.1
5. Outpost guard	26	9.9	± 7.87	257.4
6. Bunker guard	7	7.1	± 6.46	49.7
7. Ground guard	46	12.9	± 20.63	593.4
8. Foxhole guard	52	9.5	± 12.32	494.0
D. Transport - Total	37	8.5	± 5.76	314.5
1. Open vehicle	26	7.1	± 6.17	184.6
2. Closed vehicle	0	-	-	-
3. Tank, inside	11	11.8	± 3.92	129.8
4. Tank, outside	0	-	-	-
E. Miscellaneous - Total	45	6.6	± 7.33	297.0
1. Artillery	1	2.0	-	2.0
2. Wire laying	5	6.0	± 3.16	30.0
3. Construction	1	10.0	-	10.0
4. Behind M.L.R.	8	4.0	± 3.23	32.0
5. Activities on M.L.R. other than above	30	7.4	± 8.60	222.0
GRAND TOTAL	440	9.0	± 11.49	3960.0

time required to produce cold injury.

E. Duration of Exposure and Severity of Injury

On the same rationale that severity of frostbite should increase with colder temperatures one can postulate that such severity should increase with duration of exposure. Although increasing mean hours of exposure were noted for increasing degrees of frostbite of the feet (Table 26) the differences were not statistically significant at the 5% level, but the comparison between first and fourth degree foot injuries approached such significance. This tendency was not noted for hand cases (Table 27). It should be pointed out, however, that exposure

TABLE 26

DISTRIBUTION OF 548 FOOT FROSTBITE CASES ACCORDING TO DURATION OF EXPOSURE AND MAXIMUM DEGREE OF INJURY KOREA, 1951-52

Duration of Exposure (Hours)	Maximum Degree of Injury - Feet								Total	
	First		Second		Third		Fourth			
	No.	%	No.	%	No.	%	No.	%	No.	%
0 - 4	79	34.2	56	33.3	37	30.1	5	19.2	177	32.3
4.1 - 8	61	26.4	46	27.4	27	22.0	5	19.2	139	25.4
8.1 - 12	39	16.9	28	16.7	25	20.3	5	19.2	97	17.7
12.1 - 16	21	9.1	11	6.5	8	6.5	1	3.8	41	7.5
16.1 - 20	1	0.4	4	2.4	3	2.4	2	7.7	10	1.8
20.1 - 24	11	4.8	6	3.6	9	7.3	2	7.7	28	5.1
1-2 Days	9	3.9	3	1.8	10	8.1	5	19.2	27	4.9
2-3 Days	4	1.7	7	4.2	1	0.8	0	0	12	2.2
> 3 Days	6	2.6	7	4.2	3	2.4	1	3.8	17	3.1
Total	231	100.0	168	100.0	123	99.9	26	99.8	548	100.0
Mean	11.0 Hrs.		12.3 Hrs.		12.4 Hrs.		17.2 Hrs.		12.1 Hrs.	
S. D.	± 15.57		± [illegible]		± 15.45		± 18.61		± [illegible]	

TABLE 27

DISTRIBUTION OF 112 HAND FROSTBITE CASES ACCORDING TO DURATION OF EXPOSURE AND MAXIMUM DEGREE OF INJURY KOREA, 1951-52

Duration of Exposure (Hours)	Maximum Degree of Injury - Hands								Total	
	First		Second		Third		Fourth			
	No.	%	No.	%	No.	%	No.	%	No.	%
0 - 4	14	48.3	45	65.2	6	60.0	2	50.0	67	59.8
4.1 - 8	8	27.6	16	23.2	2	20.0	2	50.0	28	25.0
8.1 - 12	4	13.8	4	5.8	2	20.0	0	0	10	8.9
12.1 - 16	3	10.3	2	2.9	0	0	0	0	5	4.5
16.1 - 20	0	0	0	0	0	0	0	0	0	0
20.1 - 24	0	0	1	1.4	0	0	0	0	1	0.9
1-2 Days	0	0	1	1.4	0	0	0	0	1	0.9
2-3 Days	0	0	0	0	0	0	0	0	0	0
> 3 Days	0	0	0	0	0	0	0	0	0	0
Total	29	100.0	69	99.9	10	100.0	4	100.0	112	100.0
Mean	5.5 Hrs.		4.5 Hrs.		4.4 Hrs.		4.0 Hrs.		4.7 Hrs.	
S. D.	± 4.17		± 5.27		± 3.56		± 2.67		± 4.75	

time for frostbite of the hands was significantly lower (P <.001) than for the feet, degree for degree of injury. This result may be misleading in view of the earlier discussion on temperature and windchill in relation to site of injury. The hands, it will be recalled, required a lower temperature for occurrence of frostbite, probably for the reasons expressed. One would then expect the hands to require longer exposures as well. This would be logical to assume if the conditions with respect to adequacy of handwear at time of exposure were comparable to the situation in regard to bootgear. A significantly

greater percentage (15.9) of hand cases (Table 62) were frostbitten as a result of removal of gear than were feet (0.5%, Table 61). Thus it may be said that hands were relatively more frequently exposed to more intense cold, although for shorter periods of time, without protective gear than were feet.

F. Gradient of Injury

Fully recognizing the multiplicity of factors which may modify cold injury, it nevertheless was thought that it might be fruitful to explore more fully the possibility of some combination of agent and environmental factor which bears a direct and simple relationship to degree of injury. The establishment of a gradient of injury under varying conditions would then become a reality. It will be recalled that temperature and duration of exposure, analyzed separately, revealed some slight, if not significant, trends in this direction. It is obvious that each can contribute to the total effect and influence or modify the effect of the other. Thus a combination of the intensity of the agent factor (cold) and the duration of its action (time of exposure) appeared to be more logical in establishing a gradient of severity of injury.

An attempt was made in devising an "exposure-index" (E.I.) to combine these two factors. The index was arbitrarily defined as the product of the duration of exposure (D, in hours) and the reciprocal of the minimum temperature of exposure ($\frac{1}{T}$, in °F). To all temperatures a constant (10°) was added to obviate

negative values.* In Table 28, "exposure-indices" for Whites and Negroes have been calculated according to degree of injury of the feet. Trends were noted but the differences were not statistically significant. The differences between the races at the several degree of injury levels were also not significant except for third degree injury. Thus, in this experience as well an attempt to establish a significant gradient of injury was not too successful. It became obvious that further refinement of the data would be necessary. This would entail the detailed study of a much larger frostbite experience for several factors would have to be held constant (e.g. combat activity and bootgear) in order that ultimate categories would contain large enough numbers of cases. However, another criterion must not be overlooked. This criterion involves the basis for diagnosis of severity of injury. To the present time severity has been classed according to degree. Degree diagnosis has involved, for the most part, estimation of the depth of injury and not the total area involved. There was the possibility that this shortcoming may have detracted in part from a significant linear gradient of injury.

G. Weather Type

Table 29 outlines the types of weather to which the frostbite cases and controls were exposed. The higher incidence of cases

*Dr. A. C. Burton, Department of Biophysics, University of Western Ontario Medical School personally suggested to the author the use of decrements of temperature (increasing amounts of cold) from a reference temperature at which no frostbite occurs, thus obviating adding of constants and the use of reciprocals (9).

RESTRICTED
Security Information

TABLE 28

EXPOSURE-INDICES (E.I.= D X $\frac{1}{T}$) FOR 298 WHITE AND 208 NEGRO CASES OF FROSTBITE OF THE FEET AND FEET AND HANDS BY DEGREE OF INJURY KOREA, 1951-52

Degree of Injury	Exposure Index					
	White			Negro		
	No.	Mean	Standard Deviation	No.	Mean	Standard Deviation
First	138	0.73	± 1.78	74	0.50	± 0.94
Second	96	0.81	± 1.14	64	0.76	± 1.58
Third	52	0.91	± 1.11	58	0.42	± 0.43
Fourth	12	0.92	± 1.10	12	0.85	± 1.23
Total	298	0.79	± 1.47	208	0.58	± 1.11

D = Duration of exposure in hours.
T = Minimum temperature of exposure in degrees F.

TABLE 29

DISTRIBUTION OF 648 CASES OF FROSTBITE AND 444 BUNKER-MATE CONTROLS ACCORDING TO TYPE OF WEATHER TO WHICH THEY WERE EXPOSED KOREA, 1951-52

Weather Type	Cases		Controls	
	No.	%	No.	%
Clear to partly cloudy	451	69.6	299	67.3
Cloudy to overcast	73	11.3	32	7.2
Blowing snow, sand or dust	4	0.6	38	8.6
Foggy	4	0.6	4	0.9
Drizzle	3	0.5	2	0.5
Raining	15	2.3	8	1.8
Thunderstorm with rain or hail	0	-	0	-
Sleet or freezing rain	14	2.2	10	2.3
Snow	84	13.0	51	11.5
Total	648	100.1	444	100.1

RESTRICTED
Security Information

during clear or partly cloudy weather was compatible with the lower temperature encountered with this type of weather during winter (a clear or partly cloudy sky permits more heat loss from the earth's surface during the night). Of interest was the extremely low incidence of cases during rainy weather, which was merely a reflection of the low incidence of rainy days during the winter season. This latter in turn accounted for the absence of true trenchfoot in the Korean theatre. No relation between degree of injury and type of weather could be demonstrated for either foot or hand injuries (Tables 30 and 31).

TABLE 30

DISTRIBUTION OF 518 CASES OF FROSTBITE OF THE FEET ACCORDING TO WEATHER TYPE TO WHICH EXPOSED AND MAXIMUM DEGREE OF INJURY
KOREA, 1951-52

Weather Type	Maximum Degree of Injury - Feet								Total	
	First		Second		Third		Fourth			
	No.	%	No.	%	No.	%	No.	%	No.	%
Clear to partly cloudy	145	69.4	120	72.7	62	53.0	18	66.7	345	66.6
Cloudy to overcast	21	10.0	21	12.7	[illegible]	13.7	5	18.5	63	12.2
Blowing snow, sand or dust	0	0	1	0.6	2	1.7	0	0	3	0.6
Foggy	2	1.0	0	0	2	1.7	0	0	4	0.8
Drizzle	1	0.5	0	0	1	0.9	0	0	2	0.4
Raining	6	2.9	2	1.2	4	3.4	0	0	12	2.3
Thunderstorm with rain or hail	0	0	0	0	0	0	0	0	0	0
Sleet or freezing rain	8	3.8	1	0.6	3	2.6	1	3.7	13	2.5
Snow	26	12.4	20	12.1	27	23.1	3	11.1	76	14.7
Total	209	100.0	165	99.9	117	100.1	27	100.0	518	100.1

Chi square = 27.975 df = 21 P >.10

RESTRICTED
Security Information

TABLE 31

DISTRIBUTION OF 112 CASES OF FROSTBITE OF THE HANDS ACCORDING TO TYPE OF WEATHER TO WHICH EXPOSED AND MAXIMUM DEGREE OF INJURY KOREA, 1951-52

Weather type	Maximum Degree of Injury - Hands								Total	
	First		Second		Third		Fourth			
	No.	%	No.	%	No.	%	No.	%	No.	%
Clear to partly cloudy	22	78.6	52	76.5	9	90.0	6	100.0	89	79.5
Cloudy to overcast	2	7.1	7	10.3	0	-	0	-	9	8.0
Blowing snow, sand or dust	0	-	1	1.5	0	-	0	-	1	0.9
Foggy	0	-	0	-	0	-	0	-	0	-
Drizzle	1	3.6	0	-	0	-	0	-	1	0.9
Raining	0	-	3	-	0	-	0	-	3	2.7
Thunderstorm with rain or hail	0	-	0	-	0	-	0	-	0	-
Sleet or freezing rain	0	-	1	1.5	0	-	0	-	1	0.9
Snow	3	10.7	4	5.9	1	10.0	0	-	8	7.1
Total	28	100.0	68	100.1	10	100.0	6	100.0	112	100.0

Chi square = 9.540 df = 18 P >.90

H. Terrain

The Korean terrain has been described in the introduction. Actually the incidence of cases distributed according to terrain in Table 32 reflected the terrain itself and no special significance may be attached to the relative incidence. The distinctions between flat and valley and between hill and mountain were at best, arbitrary and not constant for the cases as compared to the controls. For this reason a simple dichotomy was utilized in comparing terrain with degree of injury in frostbite of the feet (Table 33) and in hands (Table 34). No

RESTRICTED
Security Information

significant relationship between terrain and degree of injury could be found.

TABLE 32

DISTRIBUTION OF 679 CASES OF FROSTBITE AND 447 BUNKER-MATE CONTROLS ACCORDING TO TYPE OF TERRAIN IN WHICH INJURY WAS INCURRED KOREA, 1951-52

Terrain	Cases		Controls	
	No.	%	No.	%
Flat	64	9.4	13	2.9
Valley	93	13.7	80	17.9
Hill	333	49.0	184	41.2
Mountain	189	27.8	170	38.0
Total	679	99.9	447	100.0
Chi square = 3.178 df = 1 P >.05				

TABLE 33

RELATION OF DEGREE OF INJURY TO TERRAIN WHERE INJURY WAS INCURRED BY 546 CASES OF FROSTBITE OF THE FEET KOREA, 1951-52

Terrain	Maximum Degree of Injury - Feet								Total	
	First		Second		Third		Fourth			
	No.	%	No.	%	No.	%	No.	%	No.	%
Flat	27	11.7	15	8.8	5	4.2	1	3.7	48	8.8
Valley	30	13.0	17	10.1	17	14.2	1	3.7	65	11.9
Hill	110	47.8	78	46.2	70	58.3	21	77.8	279	51.1
Mountain	63	27.4	59	34.9	28	23.3	4	14.8	154	28.2
Total	230	99.9	169	100.0	120	100.0	27	100.0	546	100.0
Chi square = 5.952 df = 3 P >.10										

TABLE 34

RELATION OF DEGREE OF INJURY TO TERRAIN WHERE INJURY
WAS INCURRED BY 111 CASES OF FROSTBITE OF THE HANDS
KOREA, 1951-52

Terrain	Maximum Degree of Injury - Hands								Total	
	First		Second		Third		Fourth			
	No.	%	No.	%	No.	%	No.	%	No.	%
Flat	4	13.8	6	9.0	2	20.0	0	---	12	10.8
Valley	6	20.7	11	16.4	3	30.0	2	40.0	22	19.8
Hill	10	34.5	31	46.3	5	50.0	2	40.0	48	43.2
Mountain	9	31.0	19	28.4	0	---	1	20.0	29	26.1
Total	29	100.0	67	100.1	10	100.0	5	100.0	111	99.9

Chi square = 3.013 df = 3 P >.30

I. Condition of the Ground Surface

Since wetness can be a synergist in cold injury especially when seepage through leather combat boots can occur and deep snow can enter over the tops of boots, it was of interest to note that, for the experience as a whole and irrespective of site of injury, wetness of the ground did not play a major role in this series of frostbite cases (Table 35). Virtually 85% of the cases occurred when the ground was dry or snow so shallow that it could not enter over boot tops. However, a major exception to this statement was the cases of frostbite during the first cold wave of the winter, the majority of which occurred with the men in leather boots. For these, wetness can be considered a factor in rapid heat withdrawal.

On examin[illegible] the data with respect to site and degree of

TABLE 35

DISTRIBUTION OF 642 CASES OF FROSTBITE AND 442 BUNKER-MATE CONTROLS ACCORDING TO CONDITION OF GROUND SURFACE ENCOUNTERED DURING EXPOSURE KOREA, 1951-52

Ground Surface Condition	Cases		Controls	
	No.	%	No.	%
Dry ground	74	11.5	37	8.4
Wet ground	14	2.2	4	0.9
Muddy	34	5.3	12	2.7
Slushy	19	3.0	18	4.1
Snow < 2 inches	314	48.9	186	42.1
Snow 3-5 inches	158	24.6	115	26.0
Snow 6-8 inches	17	2.6	38	8.6
Snow 9-11 inches	8	1.2	9	2.0
Snow > 1 foot	4	0.6	23	5.2
Total	642	99.9	442	100.0
Chi square = 5.596 df = 2 P >.05				

injury, it was noted that a distinct and significant relation existed between degree of injury of the feet and condition of the ground (Table 36). Dry ground was more often associated with lower degrees of injury and wet ground more often with higher degrees of frostbite. Although many hand injuries were associated with wet gloves, the degree of injury in this site was apparently not associated with any specific condition of the ground surface (Table 37).

J. Combat Action

The role of combat activity in increasing the incidence of cold injury has been demonstrated in the European Theatre of Operation (4) and its effect on frostbite incidence in Korea

RESTRICTED
Security Information

TABLE 36

RELATION OF DEGREE OF INJURY TO CONDITION OF THE SURFACE OF THE GROUND WHERE INJURY WAS INCURRED BY 513 CASES OF FROSTBITE OF THE FEET KOREA, 1951-52

Ground Surface Condition	Maximum Degree of Injury - Feet								Total	
	First		Second		Third		Fourth			
	No.	%	No.	%	No.	%	No.	%	No.	%
Dry ground	34	15.5	17	10.4	9	7.8	1	3.7	61	11.9
Wet ground	5	2.4	3	1.8	1	0.9	2	7.4	11	2.1
Muddy	12	5.8	4	2.4	12	10.3	3	11.1	31	6.0
Slushy	7	3.4	5	3.0	6	5.2	0	--	18	3.5
Snow < 2 inches	102	49.5	82	50.0	51	44.0	10	37.0	245	47.8
Snow 3-5 inches	42	20.4	48	29.3	27	23.3	8	29.6	125	24.4
Snow 6-8 inches	2	1.0	4	2.4	6	5.2	3	11.1	15	2.9
Snow 9-11 inches	1	0.5	1	0.6	3	2.6	0	--	5	1.0
Snow > 1 foot	1	0.5	0	--	1	0.9	0	--	2	0.4
Total	206	100.0	164	99.9	116	100.1	27	99.9	513	100.0

Chi square = 14.368 df = 6 P ..05

suggested (7). It is extremely logical that intense combat would be productive of increased cold injury for such action implies restriction of freedom of movement, prolongation of exposure, lack of opportunity to rewarm, increased difficulties in logistical support (especially food and clothing) and neglect of personal hygiene. Intense combat also contributes to those factors which in turn have more or less subtle modifying effects on cold injury production, for example fatigue and morale.

The several levels of combat action may be graded as follows (from heaviest to lightest activity):

1) Active offense with major fighting or active defense with attack.

RESTRICTED
Security Information

2) Active defense with minor fighting.

3) Static defense with patrolling and line holding.

4) Reserve and rest.

TABLE 37

RELATION OF DEGREE OF INJURY TO CONDITION OF THE SURFACE OF THE GROUND WHERE INJURY WAS INCURRED BY 112 CASES OF FROSTBITE OF THE HANDS KOREA, 1951-52

Ground Surface Condition	Maximum Degree of Injury - Hands								Total	
	First		Second		Third		Fourth			
	No.	%	No.	%	No.	%	No.	%	No.	%
Dry ground	4	14.3	5	7.4	2	20.0	0	--	11	9.8
Wet ground	1	3.6	2	2.9	0	--	0	--	3	2.7
Muddy	0	--	2	2.9	0	--	0	--	2	1.8
Slushy	0	--	1	1.5	0	--	0	--	1	0.9
Snow < 2 inches	17	60.7	33	48.5	3	30.0	5	83.3	58	51.8
Snow 3-5 inches	4	14.3	21	30.9	4	40.0	1	16.7	30	26.8
Snow 6-8 inches	1	3.6	0	--	1	10.0	0	--	2	1.8
Snow 9-11 inches	0	--	3	4.4	0	--	0	--	3	2.7
Snow > 1 foot	1	3.6	1	1.5	0	--	0	--	2	1.8
Total	28	100.1	68	100.0	10	100.0	6	100.0	112	100.1
Chi square = 4.273 df = 6 P >.50										

It already has been mentioned that the activity in Korea during the winter of 1951-52 was much less intense than in the winter of 1950-51. Although the inadequate supply of clothing and the colder temperatures of Northern Korea during December 1950 contributed in part toward a greater incidence of frostbite, the rapid swing of action from active offense to active defense probably was the major factor in this incidence. In the winter of 1951-52, however, the only relatively heavy action in the form of active defense of friendly positions with minor fighting

occurred in November, while the balance of the winter saw the Eighth Army on static defense with patrolling and line holding and regiments rotating routinely to reserve areas for rest.

A rank-order correlation of mean regimental monthly frostbite rates derived from Table 6 with their mean monthly battle casualty rates derived from Appendix Table 3 was attempted but no correlation was found, although some regiments with low battle casualty rates also showed low frostbite rates (Table 38). This need not be considered as indicating lack of relationship between combat activity (as measured by battle casualty rates) and frostbite for other factors may so modify the effect as to obscure this relationship. A clue to the suspicion that different factors were operative over the respective months was found in the significant positive correlation (Table 39) between cold injury rates and battle casualty rates in December when general activity was considerably less. Another approach was therefore attempted. This involved an analysis of the effect on cold injury rates by standardizing battle casualty rates i.e. correcting for combat action. This was done by dividing the monthly frostbite rates for each unit by the respective monthly battle casualty rates and multiplying by 100. Thus the derived frostbite rates were on the basis of 100 battle casualties per 1,000 strength per annum for each and every unit (Table 40). Several important points become apparent by inspection of this table and comparison with Table 6. Considering the Eighth Army as a whole and correcting for differences in combat activity the

RESTRICTED
Security Information

TABLE 38

COMPARISON OF MEAN MONTHLY COLD INJURY RATES WITH MEAN MONTHLY BATTLE CASUALTY RATES AMONG 21 UNITED STATES REGIMENTS KOREA, 1951-52

Division and Regiment	Mean Battle Casualty Rate		Mean Cold Injury Rate	
2nd Infantry Division				
9th Regiment	46.9	(20)*	2.7	(19)
23rd Regiment	40.1	(21)	2.3	(20)
38th Regiment	60.1	(16)	5.7	(17)
3rd Infantry Division				
7th Regiment	83.2	(15)	32.6	(5)
15th Regiment	202.2	(3)	14.7	(13)
65th Regiment	134.4	(9)	29.2	(7)
7th Infantry Division				
17th Regiment	183.3	(5)	87.3	(1)
31st Regiment	175.4	(6)	12.6	(14.5)
32nd Regiment	269.9	(2)	24.9	(9)
24th Infantry Division				
5th Regiment	157.9	(7)	30.5	(6)
19th Regiment	280.1	(1)	10.2	(16)
21st Regiment	191.1	(4)	28.5	(8)
25th Infantry Division				
14th Regiment	83.9	(13)	3.7	(18)
27th Regiment	103.6	(11)	0.6	(21)
35th Regiment	125.1	(10)	19.2	(10)
40th Infantry Division				
160th Regiment	70.1	(17)	37.4	(4)
223rd Regiment	51.6	(19)	74.6	(2)
224th Regiment	155.0	(8)	12.6	(14.5)
45th Infantry Division				
179th Regiment	97.7	(12)	18.9	(11)
180th Regiment	68.5	(18)	38.0	(3)
279th Regiment	83.3	(14)	17.9	(12)

*Numbers in parenthesis indicate rank in rank-order correlation. rho = 0.0640 P >.10

RESTRICTED
Security Information

TABLE 39

COEFFICIENTS OF CORRELATION BETWEEN BATTLE CASUALTY RATES AND COLD INJURY RATES BY MONTHS FOR 21 UNITED STATES REGIMENTS KOREA, 1951-52

Month & Year	Coefficient of Correlation	P
Nov. 1951	-0.0728	>.10
Dec. 1951	+0.6548	<.01
Jan. 1952	+0.1622	>.10
Feb. 1952	+0.2911	>.10
Mar. 1952	+0.4285	>.05
Nov. - Mar.	+0.1358	>.10

derived monthly cold injury rates for January and February became much higher than observed and distinctly higher than the derived rate for November. This was taken to mean that, had the same combat activity (as measured by battle casualty rates) prevailed month by month, the rates in January and February would have been higher than they actually were and the November frostbite rate would not then have been the highest for the season. This calculation also uncovered a second point, namely the true effect of low January and February temperatures on the frostbite rates as compared to the higher temperatures of November, December and March. Referring to Appendix Table 1 and Figure 3, it will be noted that the January and February mean temperatures were lowest for the season. Thus it can be seen that the seasonal or temperature factor could be hidden by interaction with combat activity.

A third point was also inferred since this calculation (Table

RESTRICTED
Security Information

TABLE 40

THE RELATION OF COLD INJURY RATES TO BATTLE CASUALTY RATES AMONG UNITED STATES DIVISIONS AND REGIMENTS IN KOREA, NOVEMBER 1951 - MARCH 1952

Unit	Cold Injury / Battle Casualty Ratios by Month				
	November	December	January	February	March
1st Cav. Div.	2.0	-	-	-	-
5 Reg.	22.3	-	-	-	-
7 Reg.	0.6	-	-	-	-
8 Reg.	3.0	-	-	-	-
Support	0.0	-	-	-	-
1st Mar. Div.	1.4	1.0	3.0	-	-
2nd Inf. Div.	59.4	6.1	13.3	4.7	1.8
9 Reg.	-	16.7	7.0	4.4	-
23 Reg.	-	-	-	22.3	16.6
38 Reg.	-	5.0	11.7	-	-
Support	20.0	-	477.8	-	-
3rd Inf. Div.	19.9	5.7	12.4	5.2	-
7 Reg.	79.4	7.0	49.8	-	-
15 Reg.	9.5	5.0	-	7.0	-
65 Reg.	3037.8	3.7	9.7	-	-
Support	0.5	100.0	200.0	25.4	-
7th Inf. Div.	31.8	7.7	6.4	21.7	20.0
17 Reg.	125.6	10.5	8.7	13.4	-
31 Reg.	2.8	3.3	12.1	43.0	-
32 Reg.	1.3	2.9	15.4	21.5	-
Support	-	-	-	-	-
24th Inf. Div.	5.6	11.4	65.5	-	-
5 Reg.	7.8	15.4	171.2	-	-
19 Reg.	2.1	6.3	11.2	-	-
21 Reg.	9.7	8.9	91.6	-	-
Support	6.3	100.0	19.4	-	-
25th Inf. Div.	4.9	9.0	231.3	36.9	1.5
14 Reg.	-	2.7	-	16.8	-
27 Reg.	1.0	-	-	-	-
35 Reg.	5.3	20.0	67.1	154.5	2.8
Support	-	-	-	-	-
40th Inf. Div.	-	-	105.9	49.0	-
160 Reg.	-	-	62.5	94.8	-
223 Reg.	-	-	300.2	95.2	-
224 Reg.	-	-	-	9.6	-
Support	-	-	-	150.0	-
45th Inf. Div.	-	64.[illegible]	44.3	110.5	3.0
179 Reg.	-	-	27.8	512.1	4.2
180 Reg.	-	38.5	97.0	100.0	-
279 Reg.	-	-	20.0	39.1	-
Support	-	-	265.9	-	100.0
Misc. Eighth Army	21.1	14.6	73.9	-	-
Total	13.2	9.5	28.5	34.2	1.3

RESTRICTED
Security Information

40) did not reduce the November frostbite rate below the December rate despite the fact that December temperatures were lower. There thus suggested itself the presence of a third factor operative in the month of November. The two possibilities which presented themselves were lack of proper bootgear and lack of acclimatization for the first wave of cold weather. The former was a highly documented fact for several regiments whereas the latter is, thus far, hypothetical conjecture. It would seem that, if not the sole remaining factor in the relatively high November incidence rate, the lack of proper bootgear did contribute materially to the high rate. This impression was supported by the fact that the higher November rate for the Eighth Army was mainly contributed to by the excessive rates of several regiments (Table 40). These regiments were the units who wore improper bootgear during the last week of November when a cold wave appeared and the enemy attacked.

Having noted the general effect of combat activity on the incidence of frostbite, it was deemed advisable to evaluate the relative effect on the incidence in the three situations peculiar to the Korean experience of 1951-52. The three situations refer to the active defense period in November, the static defense for the balance of the winter and the reserve status of the units throughout the winter. Table 16 presents the case incidence for infantry regiments on a total man-days exposure basis at the several temperature levels. These were calculated for total regiment-days in the line and total regiment-days in reserve for the period 1 December 1951 to 17 March 1952. It was

noted that at each average temperature interval the incidence was larger (approximately two times) for the regiments in the line than for those in reserve. The units in the line were not different from the units in reserve since regiments exposed in the line were later exposed in reserve and vice versa. Therefore the two groups were homogeneously constituted. Usually one infantry regiment of a division was in reserve with the other two in the line. The regiment in reserve then replaced the regiment longest in the line. Table 16 shows that the risk of attack by frostbite in the line was twice as great as for the regiment in reserve. This applies to the conditions of a front engaged in static defense.

The exclusion of the 10-day period in November 1951 (21st to 30th inclusive) from Table 16 was deliberate for this 10-day period was characterized by active defense with minor fighting. Table 41 reflects this difference in the two periods in dramatic fashion. In accepting the tenfold increase in incidence as due to the greater combat intensity, caution should be exercised, for there also was included in this period the demonstrated factor of grossly inadequate bootgear.

Whayne (6) has indicated the relative rates of cold injury in the European Theatre in World War II on a case per division per day basis for reserve, static defense and active defense types of combat activity. The data for frostbite in the Korean Theatre, 1951-52 were calculated on the basis of cases per regiment per day for the three combat situations, and the European data

TABLE 41

COMPARISON OF REGIMENTAL LINE AND RESERVE FROSTBITE RATES IN CASES PER 100,000 MAN-DAYS OF EXPOSURE AT THE SEVERAL DAILY AVERAGE TEMPERATURES KOREA, 21-30 NOV. 1951 INCLUSIVE

Daily Average Temperature in ° F.	Line Troops				Reserve Troops			
	Reg. Days	Man-Days of Exposure	Cases	Cases per 100,000 Man-Days Exposure	Reg. Days	Man-Days of Exposure	Cases	Cases per 100,000 Man-Days Exposure
45° to 51°	14	49,513	1	2.0	7	26,068	1	3.8
38° to 44°	14	49,513	8	16.2	7	26,068	0	-
31° to 37°	16	56,873	31	54.5	13	50,674	2	3.9
24° to 30°	50	179,150	84	46.9	17	61,800	3	4.9
17° to 23°	43	149,248	85	57.0	24	87,868	5	5.7
Total	137	484,297	209	43.2	68	252,478	11	4.4

were recalculated for regiments by applying a 72% correction to the division rates (average of 72% of cases in division were in infantry regiments) and divided by three. Table 42 presents this comparison. It will be seen that trenchfoot and frostbite had similar patterns of relationship among the several types of combat activity. The ratio of incidence in active defense to that in static defense for frostbite was larger than for trenchfoot though the over-all trenchfoot rates were greater. This would suggest that combat activity with its immobilizing action was a more prominent factor in frostbite than in trenchfoot.

TABLE 42

COMPARISON OF REGIMENTAL INCIDENCE RATES IN CASES PER REGIMENT PER DAY FOR FROSTBITE IN KOREA, 1951-52 AND TRENCHFOOT IN EUROPEAN THEATRE, WORLD WAR II WITH RESPECT TO THE SEVERAL COMBAT SITUATIONS

Combat Action	Frostbite Rate Korean Theatre Cases per regiment per day	Trenchfoot Rate European Theatre** Cases per regiment per day
Reserve (a)	0.09 *	0.57
Static defense (b)	0.18	0.83
Active defense (c)	1.53	3.37
Ratios:		
a: b: c	1: 2: 17	1: 1.5: 6
b: c	1: 8.5	1: 4.1

*includes entire period 21 November 1951 to 17 March 1952.
**data recalculated from Whayne's data (6).

Since an examination of the "microclimate" yielded certain interesting relationships to frostbite, it was deemed advisable to study combat activity in even more minute detail - - "micro-activity" as it were - especially since the bulk of activity for

units as a whole was of the static defense type and dramatic day to day changes in activity did not occur. In Table 25 above the frequency of 440 cases according to specific type of activity was tabulated from detailed data for these cases and 440 controls.

When examined on the basis of contact with the enemy the largest number of cases occurred when no enemy contact was made. However, the bulk of these represented activities which obviated mobility (ambush patrol, outpost guard, ground guard and foxhole guard) and other means of maintaining warmth. The next most frequent category involved enemy contact with pinning action of which the greater number of cases occurred on the Main Line of Resistance itself.

On the basis of specific activity but irrespective of enemy contact, the bulk of the cases occurred during patrols or while standing guard in foxholes, outposts or bunkers again emphasizing the factor of relative immobility. This fact appears even more clearly in Table 43. The data for this item were obtained by a careful appraisal of the replies of the case and control to a series of questions designed to visualize the actual situation which existed at the time and thus quantitate the amount of activity. If the case occurred in a bunker, for example, the number of individuals occupying that bunker, the amount of head room and the number of guard shifts were data pertinent to an estimate of the maximum movement possible. Similarly, on an ambush patrol, a mere reply to the effect that he couldn't move or "we weren't supposed to move" was not acceptable. Information

was elicited as to whether he could and did move his arms or wiggle his fingers or whether he could roll over or swing his legs about. With this in mind it was felt that the data in Table 43 represented a reasonably good measure of degree of activity. From this table it was obvious that the cases showed a preponderance of instances of immobility. Comparison to the controls in identical situations revealed that the latter group was definitely more active.

A chi square analysis revealed that the two groups were not from the same universe and that there were significant excesses of cases above expectancy in the subgroups "sleeping" or "standing with little movement" and deficits of cases in the subgroups "lying, kneeling or sitting with considerable movement" and "standing with considerable movement". When these items were grouped into light and heavy activity a significant chi square result was obtained in a contingency table (Table 44) indicating that the frostbite group had a high degree of relative inactivity or immobility and that the control group was more active in the identical situations. This factor of muscular activity is very clearly implicated in heat production and peripheral blood flow and thus a distinct contributing factor to frostbite.

It would be logical to assume that the degree of injury was inversely related to degree of activity provided that all other factors were constant for the group. This could not be established for either hand or foot cases (Tables 45 and 46).

K. Shelter

Shelter along the lines was for the most part in bunkers, for there were no native buildings left in which to take refuge. Rewarming after patrols took place in some instances in warm-up bunkers.

TABLE 43

DISTRIBUTION OF 702 CASES OF FROSTBITE AND 455 BUNKER-MATE CONTROLS ACCORDING TO RELATIVE DEGREE OF ACTIVITY DURING EXPOSURE KOREA, 1951-52

Activity	Cases		Controls	
	No.	%	No.	%
Sleeping	30	4.3	1	0.2
Lying, kneeling, or sitting with no movement	69	9.8	51	11.2
Lying, kneeling, or sitting with little movement	195	27.8	140	30.8
Lying, kneeling, or sitting with considerable movement	17	2.4	72	15.8
Standing with no movement	19	2.7	13	2.9
Standing with little movement	199	28.3	46	10.1
Standing with considerable movement	38	5.4	63	13.8
Walking with infrequent breaks	59	8.4	29	6.4
Walking with frequent breaks	76	10.8	40	8.8
Total	702	99.9	455	100.0

Chi square = 150.803 df = 8 P <.001

A sample of 275 frostbite cases which was representative of the case load as a whole (Appendix Tables 4 a and b) was studied for type of shelter employed prior to frostbite and type of heat utilized in such shelter. Data for 251 of these cases are presented in Table 47. It will be noted that the majority (60%) had no heat even though the greater number (70%) of these were

RESTRICTED
Security Information

TABLE 44

COMPARISON BETWEEN 700 CASES OF FROSTBITE AND 455 CONTROLS WITH RESPECT TO INTENSITY OF ACTIVITY AT TIME OF EXPOSURE KOREA, 1951-52

Intensity of Activity	Cases	Controls	Total
Light	509 (460)*	251	760
Heavy	191	204	395
Total	700	455	1155
Chi square = 37.741 P <.001			

*expected number

in bunkers. This situation probably need not have prevailed since 21% of the men in bunkers did provide themselves with heat in the form of improvised stoves - usually large tin cans with twigs and C Ration cardboard cartons for fuel. The static front permitted heat in many bunkers except for one week in February when a special tactical operation forbade the use of smoke-producing fires. Although shelter can be an extremely important modifying factor in cold injury, its assessment on more than a quasi-quantitative basis was difficult. In the 1951-52 Korean experience inter-regimental comparisons and "regimental injury rate - shelter facility" correlations could not be made because of the static defense situation with its relatively more uniform combat activity and relatively similar shelter facilities along the entire front. It was necessary,

RESTRICTED
Security Information

RESTRICTED
Security Information

TABLE 45

RELATION OF DEGREE OF INJURY TO DEGREE OF ACTIVITY
AMONG 578 CASES OF FROSTBITE OF THE FEET
KOREA, 1951-52

Activity	Maximum Degree of Injury - Feet								Total	
	First		Second		Third		Fourth			
	No.	%	No.	%	No.	%	No.	%	No.	%
Sleeping	8	3.2	4	2.3	14	10.9	2	7.7	28	4.8
Lying, kneeling, or sitting with no movement	27	10.9	15	8.6	12	9.3	5	19.2	59	10.2
Lying, kneeling, or sitting with little movement	70	28.2	46	26.3	35	27.1	10	38.5	161	27.9
Lying, kneeling, or sitting with considerable movement	4	1.6	3	1.7	5	3.9	1	3.8	13	2.2
Standing with no movement	10	4.0	4	2.3	4	3.1	0	-	18	3.1
Standing with little movement	74	29.8	55	31.4	38	29.5	2	7.7	169	29.2
Standing with considerable movement	14	5.6	12	6.9	5	3.9	1	3.8	32	5.5
Walking with infrequent breaks	19	7.7	17	9.7	7	5.4	3	11.5	46	8.0
Walking with frequent breaks	22	8.9	19	10.9	9	7.0	2	7.7	52	9.0
TOTAL	248	99.9	175	100.1	129	100.1	26	99.9	578	99.9

Chi square = 31.341 df = 24 P >.10

RESTRICTED
Security Information

TABLE 46

RELATION OF DEGREE OF INJURY TO DEGREE OF ACTIVITY
AMONG 181 CASES OF FROSTBITE OF THE HANDS
KOREA, 1951-52

Activity	Maximum Degree of Injury - Hands								Total	
	First		Second		Third		Fourth			
	No.	%	No.	%	No.	%	No.	%	No.	%
Sleeping	0	-	2	2.7	1	8.3	0	-	3	1.7
Lying, kneeling, or sitting with no movement	5	5.9	5	6.7	3	25.0	4	44.4	17	9.4
Lying, kneeling, or sitting with little movement	28	32.9	22	29.3	1	8.3	3	33.3	54	29.8
Lying, kneeling, or sitting with considerable movement	2	2.4	4	5.3	0	-	0	-	6	3.3
Standing with no movement	2	2.4	1	1.3	0	-	0	-	3	1.7
Standing with little movement	28	32.9	18	24.0	2	16.7	0	-	48	26.5
Standing with considerable movement	6	7.1	1	1.3	2	16.7	0	-	9	5.0
Walking with infrequent breaks	8	9.4	9	12.0	1	8.3	0	-	18	9.9
Walking with frequent breaks	6	7.1	13	17.3	2	16.7	2	22.2	23	12.7
Total	85	100.1	75	99.9	12	100.0	9	99.9	181	100.0

Chi square = 0.091 df = 24 P >.70

therefore, to resort to a simple description of the "microlocale" of exposure (Table 48). It was noted that the bulk of the cases occurred, obviously, in situations in which little or no protective shelter could be provided.

TABLE 47

DISTRIBUTION OF 251 CASES OF FROSTBITE ACCORDING TO TYPE OF SHELTER NORMALLY EMPLOYED PRIOR TO FROSTBITE AND TYPE OF HEAT UTILIZED KOREA, 1951-52

Type of Shelter	No. of Cases by Type of Heat							Total
	No Data	None	Tent Stove	Improvised Stove	Yukon Stove	Heat Tablets	Candles	
None	--	39	--	--	--	--	--	39
Bunker, 2 man	15	48	--	13	--	6	1	83
Bunker, >2 man	5	47	4	21	1	--	--	78
Squad tent	2	1	37	--	--	--	--	40
Hexagonal tent	--	--	1	--	6	--	--	7
Shelter - half tent	--	1	--	--	--	--	--	1
Building	--	1	2	--	--	--	--	3
Total	22	137	44	34	7	6	1	251

I. Clothing

Protection against cold and wet by means of clothing is certainly a primary consideration in temperate, subarctic and arctic climates. In warfare, with its frequently necessary prolonged exposure under conditions of stress, proper clothing becomes ever more essential to welfare and survival. Clothing, by retention of body heat, remains an important modifying factor in cold injury and specifically frostbite. Furthermore, adequate body clothing as distinct from foot and handgear is

RESTRICTED
Security Information

TABLE 48

DISTRIBUTION OF 700 CASES OF FROSTBITE
ACCORDING TO LOCATION AT TIME OF INJURY
KOREA, 1951-52

Location of Patient	Cases	
	No.	%
On top of ground	412	58.9
In foxhole	153	21.9
In vehicle	86	12.3
In tent or building	22	3.1
In bunker	27	3.8
Total	700	100.0

relatively more important in the prevention of frostbite than in prevention of trenchfoot. In the latter, wetness of the extremity is instrumental in increasing loss of heat from that extremity whereas in the former, a low ambient temperature plays the major role and is responsible for heat loss from the entire body. Loss of body heat because of inadequate body clothing thus contributes to cooling of the extremities.

It was of interest then to assess the role of body clothing and foot and handgear in the production of cold injury. Unfortunately, the data on body clothing were obtained for only a sample of the patients and for none of the controls. Foot and handgear data, however, were available from the basic interviews of patients and bunker-mate controls. For the body clothing survey, 275 frostbitten patients were interviewed by the Quartermaster Corps observer attached to the team. The data were obtained by questioning patients as to the gear worn

RESTRICTED
Security Information

at the time of their frostbite. This was done immediately after their arrival at the 25th Evacuation Hospital so that memory loss was insignificant. Furthermore, both pictures and actual items of gear were shown the patients to determine the exact items worn at the time of injury. Assessment of adequacy of this gear for the temperature and duration of exposure by Quartermaster Corps standards for the various ensembles was made and recorded separately for the upper and lower portions of the body. Table 49 reveals the extent to which gear was adequate for the sample of cases. It will be noticed that upper and lower body clothing, headgear and handgear were relatively adequate, but bootgear was markedly inadequate. To avoid misinterpretation it should be noted that each item was measured individually. The number of individuals who had adequate gear in all categories was also calculated and it was found that 31.6% of the sample fell in this group. Thus the bulk of the sample revealed inadequacies in gear in at least one category.

This finding reflects the oft repeated aphorism that "supply does not necessarily imply use". In Section II of this report the availability of clothing supply to units was discussed and can be summarized as having been extremely good. Whayne (6) stated, "It is not enough that these supplies should be brought to the division area, but it also is essential that provision be made to supply the farthest forward small units regularly". To this could easily be appended the statement "and that command and the soldier be rigorously trained in the proper utilization

RESTRICTED
Security Information

TABLE 49

DISTRIBUTION OF A SAMPLE OF 275 CASES OF FROSTBITE
ACCORDING TO ADEQUACY OF BODY CLOTHING AND GEAR
KOREA, 1951-52

Clothing	Adequate		Inadequate		No Data		Total
	No.	%	No.	%	No.	%	No.
Upper body clothing	231	84.0	43	15.6	1	0.4	275
Lower body clothing	226	82.2	48	17.5	1	0.4	275
Headgear	263	95.6	10	3.6	2	0.7	275
Handgear	196	71.3	66	24.0	13	4.7	275
Footgear	155	56.4	119	43.3	1	0.4	275

of the gear".

Since Table 49 does not reveal the relationship of site of injury to adequacy of gear protecting the site, Table 50 is presented for that purpose. It will be noted that hand cases logically had a much larger number with inadequate combinations of handwear than might be surmised from Table 49. Foot cases also showed a higher percentage with inadequate bootgear and ear cases revealed a much greater proportion with inadequate headgear than would be indicated by Table 49. It was obvious that the findings in Table 50 were masked in Table 49 due to mutual dilution by the many hand cases and foot cases with adequate headgear, the hand and ear cases with adequate bootgear and the foot and ear cases with adequate handgear. For example, in Table 49 only 3.6% of the total cases had inadequate headgear, but actually (Table 50) five out of six or 83.3% of the <u>ear</u> cases had inadequate headgear. The significance of this deficiency was submerged by the great number of cases who had foot or hand involvement but

RESTRICTED
Security Information

whose ears were not injured probably because they had adequate headgear.

TABLE 50

RELATION OF SITE OF INJURY TO ADEQUACY OF PERTINENT GEAR AMONG 275 CASES OF FROSTBITE SELECTED AT RANDOM FROM THE TOTAL CASE LOAD KOREA, 1951-52

Site of Injury & Gear Involved	Adequacy of Gear for Injured Site				Total
	Adequate		Inadequate		
	No.	%	No.	%	
Pure hands (handwear)	13	30.2	30	69.8	43
Hand-Foot combinations*					
- (handwear)	19	65.5	10	34.5	29
- (footgear)	16	51.6	15	48.4	31
Pure feet (footgear)	93	48.9	97	51.1	190
Ears (headgear)	1	16.7	5	83.3	6
Total	142	47.5	157	52.5	299

* This includes the duplication in the hand-foot combinations: once for handwear and then for footgear.

1. Bootgear

Since bootgear as a whole, irrespective of site of injury, was most often inadequate for a greater number of cases it was deemed advisable to study the types of bootgear worn by the troops as a further insight to adequacy under the specific climatic conditions. Table 51 presents the distribution of foot cases and bunker-mate controls according to bootgear worn at time of injury. Of interest was the fact that, although many November cases occurred while several regiments were wearing leather combat boots, the greater number of cases occurred in shoepacs and furthermore the new insulated rubber combat boots did not

prevent cold injury in 16 instances. Table 51 indicates, in addition, that a significant excess of cases wore two-buckle leather combat boots as compared to the controls and a significantly smaller proportion of cases wore insulated rubber combat boots. This inadequacy was borne out further by comparison of the foot cases with hand and/or ear cases in the same experience on the hypothesis that, if the type of bootgear did affect the incidence of frostbite of the feet, then pure hand or ear cases exposed to cold but with no injury to their feet would show a significantly different distribution of bootgear (Table 52). It will be noted that the hand cases did show a markedly lower number wearing both types of leather combat boots and a very significantly greater number wearing the insulated rubber combat boot. Thus it appeared that leather combat boots were more conducive to frostbite even though more than half the cases were in shoepacs. This latter merely indicated that more of the exposed troops were in shoepacs.

In view of the above finding the relation of type of bootgear to degree of injury was next explored. Table 53 reveals a significant excess of fourth degree injuries among cases of frostbite of the feet wearing leather combat boots and a significantly greater number of less severe injuries in shoepacs. These findings led to the conclusion that shoepacs, though not too successful in preventing frostbite, did protect against more severe injuries when compared with leather combat boots.

RESTRICTED
Security Information

TABLE 51

DISTRIBUTION OF 576 CASES OF FROSTBITE OF THE FEET AND 455 BUNKER-MATE CONTROLS ACCORDING TO TYPE OF FOOTGEAR WORN AT TIME OF INJURY KOREA, 1951-52

Type of Footgear	Cases		Controls	
	No.	%	No.	%
Boots, service, combat, russet	114	19.8	107	23.5
Boots, service, combat, 2-buckle	138	24.0	66	14.5
Boots, leather, with overshoe	2	0.3	2	0.4
Shoepac	299	51.9	226	49.7
Boots, combat, rubber, insulated	16	2.8	54	11.9
Shoes, service	4	0.7	0	--
No footgear	3	0.5	0	--
Total	576	100.0	455	100.0

Chi square = 50.114 df = 6 P <.001

TABLE 52

DISTRIBUTION OF 576 FOOT CASES AND 124 HAND OR EAR CASES OF FROSTBITE ACCORDING TO THE TYPE OF FOOTGEAR WORN AT TIME OF INJURY KOREA, 1951-52

Type of Footgear	Foot Cases		Hand Cases	
	No.	%	No.	%
Boots, service, combat, russet	114	19.8	10	8.1
Boots, service, combat, 2-buckle	138	24.0	8	6.5
Boots, leather, with overshoe	2	0.3	0	--
Shoepac	299	51.9	66	53.2
Boots, combat, rubber, insulated	16	2.8	40	32.2
Shoes, service	4	0.7	0	--
No footgear	3	0.5	0	--
Total	576	100.0	124	100.0

Chi square = [illegible] df = 6 P <.001

RESTRICTED
Security Information

RESTRICTED
Security Information

TABLE 53

RELATION OF DEGREE OF INJURY TO TYPE OF FOOTGEAR WORN AT TIME OF INJURY BY 576 CASES OF FROSTBITE OF THE FEET
KOREA, 1951-52

Type Footgear	Degree of Injury - Feet									
	First		Second		Third		Fourth		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%
Boots, service, combat, russet	62	25.1	17	9.7	27	21.1	8	30.8	114	19.8
Boots, service, combat, 2-buckle	47	19.0	44	25.1	34	26.6	13	50.0	138	24.0
Boots, leather, with overshoe	0	-	0	-	2	1.6	0	-	2	0.3
Shoepac	123	49.8	112	64.0	60	46.9	4	15.4	299	51.9
Boots, combat, rubber, insulated	10	[illegible]	2	1.1	3	2.3	1	3.8	16	2.8
Shoes, service	4	1.6	0	-	0	-	0	-	4	0.7
No footgear	1	0.4	0	-	2	1.6	0	-	3	0.5
Total	247	99.9	175	99.9	128	100.1	26	100.0	576	100.0

Chi square = 57.353 df = 18 P <.001

RESTRICTED
Security Information

2. Sockgear

An analysis of sockgear worn at the time of injury was considered in view of the range of insulative protection afforded by the several types of socks and the possible constrictive combinations with bootgear which could occur. Table 54 indicates that among the cases of frostbite of the feet there was an excess of individuals wearing but a single pair of wool ski socks. A detailed comparison of this group with the corresponding group among the controls with respect to type of bootgear worn revealed a significant excess of cases wearing two-buckle leather combat boots. The possibility that this combination is a constrictive one must be borne in mind. It was obvious that better information could be derived by an analysis of bootgear-sockgear combinations. These will be discussed below.

If certain types of sockgear were inadequate in insulation value, were constrictive in certain bootgear combinations or reflected the proper combination with a type of bootgear which was conducive to frostbite as was noted above in Tables 51 and 52, then the types of sockgear should also have borne a positive relationship to severe degrees of frostbite. This was true for cases wearing two pairs of cushion sole socks (Table 55). A detailed analysis of the 41 cases in this category by comparison with similar controls in regard to type of bootgear worn showed a significant excess of cases wearing two-buckle leather combat

RESTRICTED
Security Information

TABLE 54

DISTRIBUTION OF 573 CASES OF FROSTBITE OF THE FEET AND 455 BUNKER-MATE CONTROLS ACCORDING TO TYPE OF SOCKGEAR WORN AT TIME OF INJURY KOREA, 1951-52

Type of Sockgear Worn	Cases		Controls	
	No.	%	No.	%
Socks, wool cushion sole 1 pair	177	30.9	176	38.7
Socks, wool cushion sole 2 pair	41	7.2	27	5.9
Socks, wool ski 1 pair	67	11.7	15	3.3
Socks, wool ski 2 pair	166	29.0	116	25.5
Socks, wool ski 3 pair	2	0.3	5	1.1
Socks, wool cushion sole and socks, wool ski	115	20.1	116	25.5
No socks	5	0.9	0	--
Total	573	100.1	455	100.0

Chi square = 37.975 df = 6 P <.001

boots. It can be concluded that this probably constrictive combination of two pairs of socks in leather combat boots was significantly related to more severe frostbite. Thus we have two situations each pointing to the leather combat boot as having been conducive to more severe injuries.

3. Bootgear-Sockgear Combinations

Certain standard combinations of boots and socks have been determined by Quartermaster research as being appropriate for the several ranges of ambient temperatures and ground conditions. Assuming proper fit of the boot, then a reduction in the number of sock layers, a thinner layer and for that matter the substitution of an improper boot

RESTRICTED
Security Information

TABLE 55

RELATION OF DEGREE OF INJURY TO TYPE OF SOCKGEAR WORN AT TIME OF INJURY BY 573 CASES OF FROSTBITE OF THE FEET KOREA, 1951-52

Sockgear Worn	Degree of Injury - Feet									
	First		Second		Third		Fourth		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%
Socks, wool, cushion sole, 1 pr.	85	34.6	42	24.0	39	31.0	11	42.3	177	30.9
Socks, wool, cushion sole, 2 pr.	16	6.5	11	6.3	8	6.3	6	23.1	41	7.2
Socks, wool, ski, 1 pr.	31	12.6	20	11.4	12	9.5	4	15.4	67	11.7
Socks, wool, ski, 2 pr.	68	27.6	66	37.7	28	22.2	4	15.4	166	29.0
Socks, wool, ski, 3 pr.	1	0.4	0	-	1	0.8	0	-	2	0.3
Socks, wool, cushion and socks, wool, ski	42	17.1	36	20.6	36	28.6	1	3.8	115	20.1
No socks	3	1.2	0	-	2	1.6	0	-	5	0.9
Total	246	100.0	175	100.0	126	100.0	26	100.0	573	100.1

Chi square = 37.169 df = 18 P <.01

can spell inadequate insulation for the foot for the given ambient temperature. Thus a leather boot with one pair of cushion sole socks at 0° to -10° F. is considered inadequate insulation as is also a shoepac with one pair of cushion sole socks.

On the other hand an increase in the number of sock layers over the standard or a thicker layer may produce constriction of the foot or at least increased sweating with greater heat conduction. Thus leather boots with two or three pairs of cushion sole socks or shoepacs with three pairs of wool ski socks can be constrictive. The latter can also be conducive to excessive sweating and upon immobilization lead to rapid loss of heat. Tables 56 and 58 present the bootgear-sockgear combinations for White and Negro foot cases respectively, and Tables 57 and 59, the corresponding data for bunker-mate controls. Whites and Negroes were analyzed separately since some differences were noted between them with respect to sockgear worn (See "Race", below). Significant excesses were noted among White cases wearing a single pair of cushion sole socks in leather combat boots (inadequate gear for the temperatures encountered), a single pair of cushion sole socks in shoepacs (inadequate insulation), two pairs of cushion sole socks in leather combat boots (probably constrictive) and one pair of ski socks in leather combat boots (probably constrictive). Among Negroes an excess of cases was noted wearing one pair of ski socks in leather boots (probably

RESTRICTED
Security Information

TABLE 56

DISTRIBUTION OF 333 WHITE CASES OF FROSTBITE OF THE FEET ACCORDING TO TYPES OF FOOTGEAR AND SOCKGEAR COMBINATIONS WORN AT TIME OF INJURY KOREA, 1951-52

Sockgear Worn	White Patients - Type of Footgear											
	Boots Russet		Boots 2-Buckle		Boots and Overshoe		Shoepac		Insulated Rubber Boot		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Socks, wool, cushion sole, 1 pr.	37	61.7	40	50.6	0	-	7	3.8	7	87.5	91	27.3
Socks, wool, cushion sole, 2 pr.	7	11.7	12	15.2	0	-	2	1.1	1	12.5	22	6.6
Socks, wool, ski, 1 pr.	7	11.7	17	21.5	1	100.0	17	9.2	0	-	42	12.6
Socks, wool, ski, 2 pr.	4	6.7	3	3.8	0	-	107	57.8	0	-	114	34.2
Socks, wool, ski, 3 pr.	0	-	0	-	0	-	1	0.5	0	-	1	0.3
Socks, wool, cushion sole and socks, wool, ski	5	8.3	7	8.9	0	-	50	27.0	0	-	62	18.6
No socks	0	-	0	-	0	-	1	0.5	0	-	1	0.3
Total	60	100.1	79	100.0	1	100.0	185	99.9	8	100.0	333	99.9

RESTRICTED
Security Information

TABLE 57

DISTRIBUTION OF 407 WHITE CONTROLS ACCORDING TO TYPES OF FOOTGEAR AND SOCKGEAR COMBINATIONS WORN AT TIME OF INJURY AMONG CASES KOREA, 1951-52

Sockgear Worn	White Controls - Type of Footgear											
	Boots Russet		Boots 2-Buckle		Boots and Overshoe		Shoepac		Insulated Rubber Boot		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Socks, wool, cushion sole, 1 pr.	58	63.0	40	80.0	2	100.0	2	0.9	46	95.8	148	36.4
Socks, wool, cushion sole, 2 pr.	16	17.4	4	8.0	0	-	2	0.9	0	-	22	5.4
Socks, wool, ski, 1 pr.	5	5.4	0	-	0	-	7	3.3	0	-	12	2.9
Socks, wool, ski, 2 pr.	4	4.3	1	2.0	0	-	104	48.4	1	2.1	110	27.0
Socks, wool, ski, 3 pr.	0	-	0	-	0	-	5	2.3	0	-	5	1.2
Socks, wool, cushion sole and socks, wool, ski	9	9.8	5	10.0	0	-	95	44.2	1	2.1	110	27.0
No socks	0	-	0	-	0	-	0	-	0	-	0	-
Total	92	99.9	50	100.0	2	100.0	215	100.0	48	100.0	407	99.9

RESTRICTED
Security Information

RESTRICTED
Security Information

RESTRICTED
Security Information

TABLE 58

DISTRIBUTION OF 229 NEGRO CASES OF FROSTBITE OF THE FEET ACCORDING TO TYPES OF FOOTGEAR AND SOCKGEAR COMBINATIONS WORN AT TIME OF INJURY KOREA, 1951-52

Sockgear Worn	Negro Patients - Type of Footgear											
	Boots Russet		Boots 2-Buckle		Boots and Overshoe		Shoepac		Insulated Rubber Boot		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Socks, wool, cushion sole, 1 pr.	38	74.5	33	60.0	0	-	5	4.4	7	87.5	83	36.2
Socks, wool, cushion sole, 2 pr.	4	7.8	10	18.2	0	-	4	3.5	0	-	18	7.9
Socks, wool, ski, 1 pr.	3	5.9	6	10.9	1	100.0	11	9.6	1	12.5	22	9.6
Socks, wool, ski, 2 pr.	0	-	2	3.6	0	-	49	43.0	0	-	51	22.3
Socks, wool, ski, 3 pr.	0	-	0	-	0	-	1	0.9	0	-	1	0.4
Socks, wool, cushion sole and socks, wool, ski	6	11.8	3	5.5	0	-	44	38.6	0	-	53	23.1
No socks	0	-	1	1.8	0	-	0	-	0	-	1	0.4
Total	51	100.0	55	100.0	1	100.0	114	100.0	8	100.0	229	99.9

RESTRICTED
Security Information

TABLE 59

DISTRIBUTION OF 37 NEGRO CONTROLS ACCORDING TO TYPES OF FOOTGEAR AND SOCKGEAR COMBINATIONS WORN AT TIME OF INJURY AMONG CASES KOREA, 1951-52

Sockgear Worn	Negro Controls - Type of Footgear											
	Boots Russet		Boots 2-Buckle		Boots and Overshoe		Shoepac		Insulated Rubber Boot		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Socks, wool, cushion sole, 1 pr.	6	60.0	12	92.3	0	-	0	-	4	66.7	22	59.5
Socks, wool, cushion sole, 2 pr.	3	30.0	1	7.7	0	-	0	-	0	-	4	10.8
Socks, wool, ski, 1 pr.	0	-	0	-	0	-	0	-	2	33.3	2	5.4
Socks, wool, ski, 2 pr.	0	-	0	-	0	-	4	50.0	0	-	4	10.8
Socks, wool, ski, 3 pr.	0	-	0	-	0	-	0	-	0	-	0	-
Socks, wool, cushion sole and socks, wool, ski	1	10.0	0	-	0	-	4	50.0	0	-	5	13.5
No socks	0	-	0	-	0	-	0	-	0	-	0	-
Total	10	100.0	13	100.0	0	-	8	100.0	6	100.0	37	100.0

constrictive and certainly inadequate insulation for the existing temperatures).

4. Extra Footwear Carried

Since socks and, in the case of shoepacs, insoles become saturated rapidly with sweat or from external liquids, thus losing their insulative qualities, the availability of extra footwear of this type of change becomes important in the prevention of cold injury. Troops are usually indoctrinated in foot hygiene, including the need for changing of socks and insoles frequently to retain adequate insulation. Such items must be made available and each soldier should carry them and take advantage of any opportunity to change socks and insoles. Certainly sock change on patrols is not expedient militarily, although in rare instances a control subject claimed to have done so. Opportunities may arise when socks can be changed and to have them on his person could mean the difference between cold injury and no cold injury to the front-line rifleman. Detailed data on ultimate unit distribution were not available but no gross evidences of inadequacy of supply were noted. The cases and controls were interviewed with regard to the extra footwear which they carried on their person or was immediately available to them in their bunkers in those instances where injuries occurred in bunkers. In Table 60 there will be seen a marked disparity with regard to this factor between the two groups. The cases showed a highly significant excess of

instances in which neither extra socks nor extra insoles were carried by them. This undoubtedly contributed to the incidence of cold injury. That this was probably not a major factor in the production of frostbite is presumed because in other instances, despite the carrying of such extra gear, a great number of injuries occurred on patrols or other situations when sock and insole change could not practically be accomplished. However that this factor was of some significance was revealed by an analysis of cases and controls exposed to low ambient temperatures in situations in which sock or insole change could have taken place expediently. In 560 cases of frostbite of the feet, 252 or 45% were in situations permitting change of socks and insoles yet only 186 or 77% of the latter carried extra footwear to change. This may be compared to 214 out of 396 controls or 54% in situations permitting change of socks with 196 or 92% of the latter carrying extra footwear for change. It would appear that extra footwear should be carried irrespective of the circumstances so that change of socks and insoles can be executed whenever the situation permits.

5. Handwear

Adequacy of handgear undoubtedly modified the occurrence of frostbite of the hands. Table 61 presents a comparison of hand cases and bunker-mate controls according to the type of handgear worn. Chi square calculations indicated that there was a highly significant excess of cases without gloves at time of injury or wearing only glove inserts, whereas too

TABLE 60

DISTRIBUTION OF 685 CASES OF FROSTBITE AND 454 BUNKER-MATE CONTROLS ACCORDING TO ITEMS OF EXTRA FOOTWEAR CARRIED AT TIME OF INJURY
KOREA, 1951-52

Extra Footwear Carried	Cases		Controls	
	No.	%	No.	%
Extra socks	214	31.2	200	44.1
Extra socks and insoles	217	31.7	206	45.4
No extra socks or insoles	204	29.8	36	7.9
Extra insoles - No extra socks	9	1.3	5	1.1
Extra socks - No extra insoles	41	6.0	7	1.5
Total	685	100.0	454	100.0

Chi square = 100.905 df = 4 P <.001

few cases wore complete mitten ensembles. This finding was further emphasized by utilizing, as controls, those cases in which only the feet were frostbitten assuming that if exposure were adequate in these cases to produce frostbite of the feet, their handwear distribution should be significantly different from that among the hand cases. Table 62 confirms this suspicion. It will be noted that a highly significant excess of hand cases wore no gloves at all or only glove inserts. Individual histories revealed that gloves removed to "unjam" automatic weapons were frequently lost suggesting the necessity for some device, as a mitten cord about the neck, to prevent such loss. Furthermore cases frequently indicated the need to remove outer shells for better manipulation of the trigger finger. This would point to the need for a more highly insulative yet thinner insert

RESTRICTED
Security Information

TABLE 61

DISTRIBUTION OF 145 CASES OF FROSTBITE OF THE HANDS AND 447 BUNKER-MATE CONTROLS ACCORDING TO HAND-GEAR WORN AT TIME OF INJURY
KOREA, 1951-52

Handgear Worn	Cases		Controls	
	No.	%	No.	%
Mittens, complete	43	29.7	211	47.2
Mittens, shell only	1	0.7	2	0.4
Mittens, insert only	5	3.4	4	0.9
Gloves, complete	56	38.6	211	47.2
Gloves, shell only	1	0.7	2	0.4
Gloves, insert only	16	11.0	8	1.8
No gloves	23	15.9	9	2.0
Total	145	100.0	447	99.9
Chi square = 76.7833 df = 6 P <.001				

TABLE 62

COMPARISON OF HANDWEAR WORN BY 377 PURE FEET FROSTBITE CASES AND 145 HAND FROSTBITE CASES
KOREA, 1951-52

Type Handwear Worn	Pure Feet Cases		Hand Cases	
	No.	%	No.	%
Mittens, complete	159	42.2	43	29.7
Mittens, shell only	0	-	1	0.7
Mittens, insert only	7	1.8	5	3.4
Gloves, complete	180	47.7	56	38.6
Gloves, shell only	3	0.8	1	0.7
Gloves, insert only	8	2.1	16	11.0
No gloves	20	5.3	23	15.9
Total	377	99.9	145	100.0
Chi square = 42.208 df = 6 P <.001				

for such purposes.

RESTRICTED
Security Information

6. Insulated Rubber Combat Boot

The new insulated rubber combat boot employing the vapor barrier principle began making its appearance among United States infantry troops shortly after 1 December 1951. The United States Marines in Korea had been fully equipped prior to the advent of cold weather but difficulties of supply by manufacturers created a problem of distribution to the rest of the United States units. The retarded distribution, however, made comparative rate studies possible, for distribution was not complete for all United States front-line units until the end of February. If the new boot would afford a high degree of protection, the ratio* of cases of frostbite of the feet to cases of frostbite of the hands should decrease with the issue of the boot to the individual front-line units. That the insulated rubber boot appeared to have reduced the foot-to-hand injury ratios among the several divisions is noted in Figure 9. The 1st Cavalry and 24th Infantry Divisions never did receive the new boot since they were withdrawn from front-line duty before the boot was issued. The 1st Cavalry was rotated early in the cold season but the 24th Infantry served a good portion of the winter and hence its ratio of cases can, in a sense, be considered a control. On the other hand the 1st Marine Division, fully equipped with the boot before cold weather set in and thus representing a unit wear-

* Absolute reductions in number of foot cases were not relied upon, since a decline in temperature could cause over-all increases and obscure decreases derived by wearing the boot.

RESTRICTED
Security Information

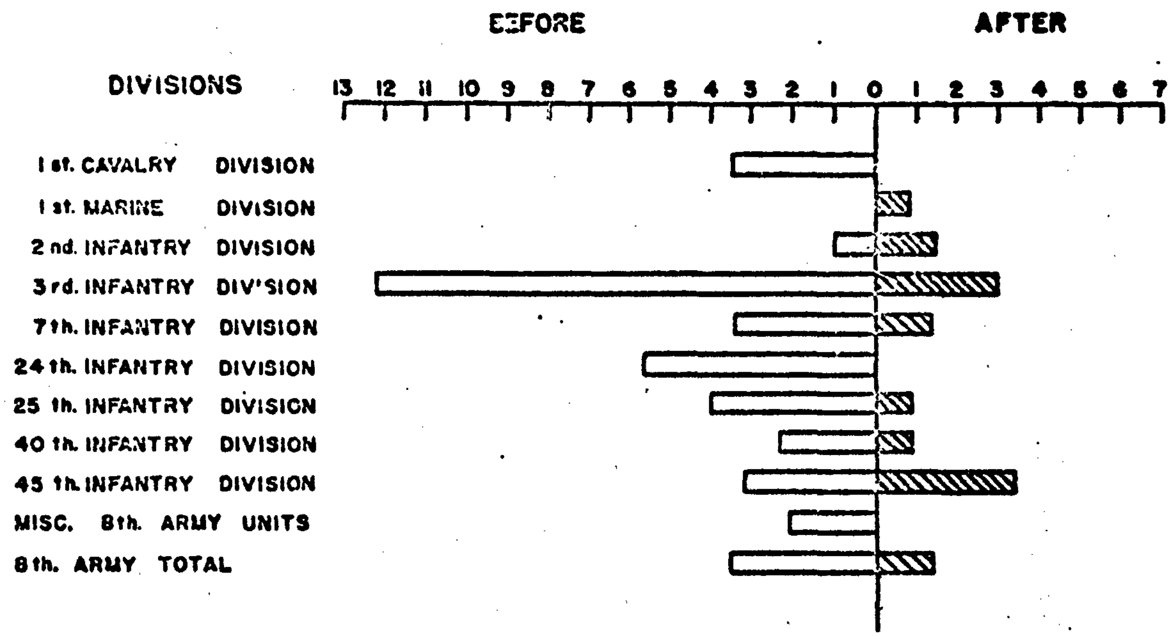


FIG. 9. RATIO OF FEET TO HAND COLD INJURY CASES BY DIVISIONS OF 8 th. ARMY BEFORE AND AFTER ISSUE OF RUBBER INSULATED COMBAT BOOT.

RESTRICTED
Security Information

ing the boot throughout the cold season, had an extremely low ratio of foot-to-hand cases similar to the ratios experienced by the 25th and 40th Infantry Divisions after they were equipped with the insulated rubber boot. Reductions were apparent in almost all units and the reduction in the ratio for the Eighth Army as a whole, including the miscellaneous support units who never received the boot, was 2.5-fold (from 3.5:1 to 1.4:1).

The relationship of the issue of the insulated rubber combat boot to the monthly ratio of foot-to-hand cases was further explored by calculating the percentage of completion of issue to regiments from data provided by the Quartermaster Corps office in Korea.* Figure 10 is presented to show this relationship. As the issue of boots proceeded and neared completion, it was apparent that the hand cases represented increasing proportions of the monthly total of cases.

If the new boot is relatively more protective against cold injury, then a reduction in incidence of the relatively more severe forms of cold injury of the feet should have been noted with increasing utilization of the boot. Figure 11 indicates such a trend. Whereas in November 32.6% of the foot injuries were third or fourth degree, in February this was reduced to 16.9% (March represented but six cases). Such a trend may also be due to a decrease in combat activity.

Thus there appeared to be evidence that the new rubber boot,

---

* Mid-month regimental strengths and mid-month data for distribution of the boot were utilized, calculating the specific fraction of a regiment completed on the basis of battalion data.

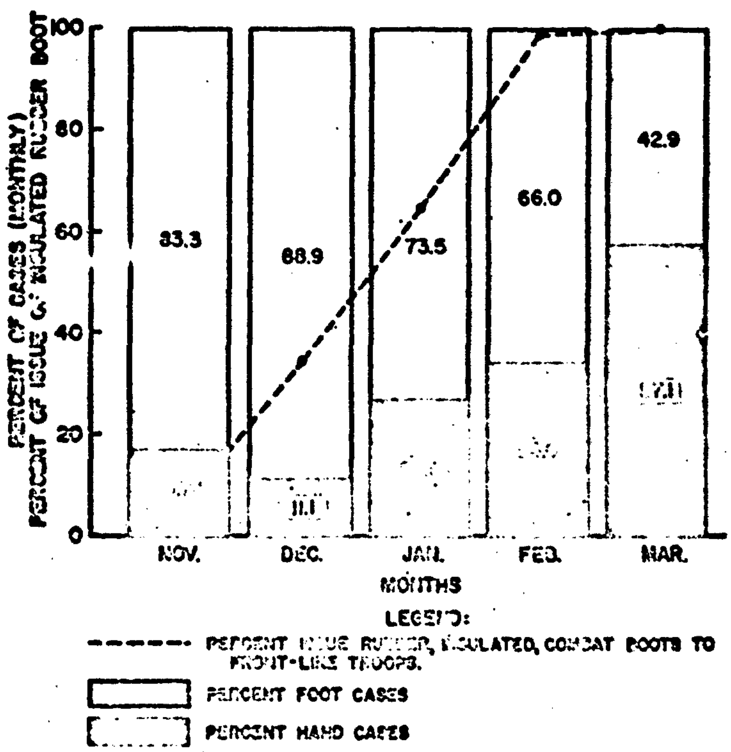


FIG. 10. MONTHLY "FOOT-TO-HAND" RATIOS OF FROSTBITE INCIDENCE WITH REFERENCE TO ISSUE OF RUBBER, INSULATED, COMBAT BOOT: KOREA, 1951-52.

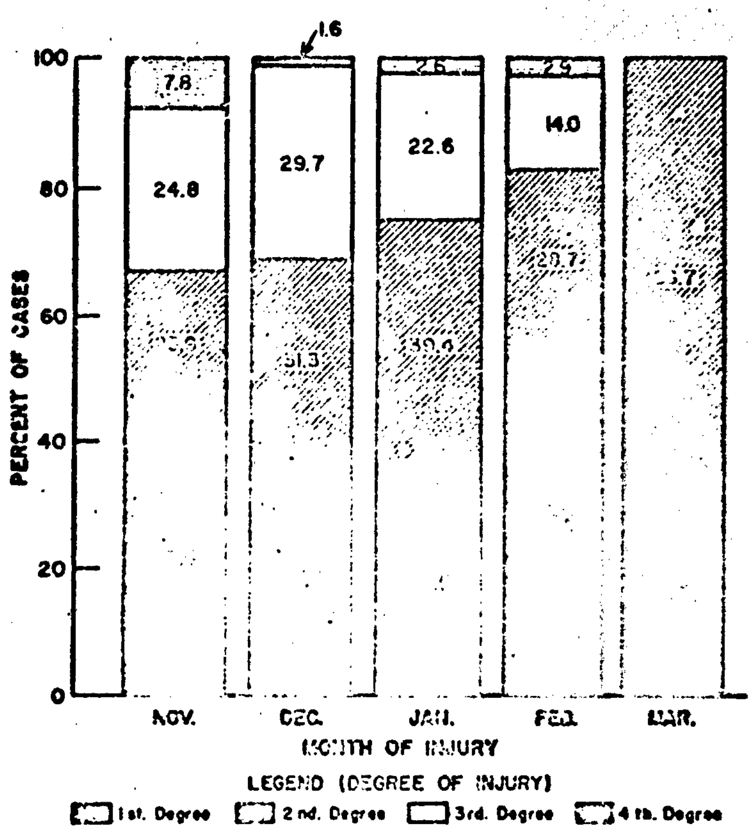


FIG. 11. RELATIVE MONTHLY INCIDENCE OF DEGREE OF INJURY IN FROSTBITE OF THE FEET — KOREA, 1951-52.

RESTRICTED
Security Information

though not completely preventing frostbite of the feet, seemed to reduce the incidence and the severity at least for conditions of combat as represented by the static defense operations in the winter of 1951-52. The protection afforded under more rigorous conditions of stress in the field (severe combat activity and very low ambient temperatures) remains to be seen.

M. Relation of Condition of Extremities to Frostbite

Although more properly a host factor because of physiologic differences in sweating among individuals, the condition of the extremities is so intimately linked with the type of gear worn that it will be discussed in relation to clothing.

Earlier it was mentioned that wetness itself did not play a major role in frostbite and that the climate and terrain in Korea was more favorable to the production of frostbite than trenchfoot. Even at lower ambient temperatures, however, wetness assists materially in cooling of the extremity by rapid conduction of heat away from the part. Thus sweat or external water can play a significant part in frostbite production. In Table 63 it can be seen that feet wet from melted snow or from wading in water were more frequently found among frostbite cases than among the controls. There was no significant number of cases with feet wet from muddy ground. This was readily accounted for by the fact that in Korea thaws rarely occurred during the winter season.

The relation between the condition of the feet and the severity of the frostbite was examined and a tendency was noted for more severe injuries to occur with wetness from external sources (Table 64).

TABLE 63

COMPARISON OF 566 CASES OF FROSTBITE OF THE FEET AND 454 BUNKER-MATE CONTROLS WITH RESPECT TO CONDITION OF FEET AT TIME OF INJURY
KOREA, 1951-52

Condition of Feet	Cases		Controls	
	No.	%	No.	%
Dry	154	27.2	113	24.9
Wet with sweat	239	42.2	238	52.5
Wet from muddy ground	9	1.6	1	0.2
Wet from melted snow	139	24.6	96	21.2
Wet from wading in water	25	4.4	5	1.1
Total	566	100.0	453	99.9

Chi square = 32.954 df = 4 P <.001

TABLE 64

RELATION OF DEGREE OF INJURY TO CONDITION OF FEET AT TIME OF INJURY AMONG 566 CASES OF FROSTBITE OF THE FEET
KOREA, 1951-52

Condition of Feet	Degree of Injury - Feet: First		Second		Third		Fourth		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%
Dry	62	25.6	44	25.4	39	31.0	9	36.0	154	27.2
Wet with sweat	105	43.4	85	49.1	45	35.7	4	16.0	239	42.2
Wet from muddy ground	1	0.4	2	1.2	4	3.2	2	8.0	9	1.6
Wet from melted snow	64	26.4	34	19.7	34	27.0	7	28.0	139	24.6
Wet from wading in water	10	4.1	8	4.6	4	3.2	3	12.0	25	4.4
Total	242	99.9	173	100.0	126	100.1	25	100.0	566	100.0

Chi square = 26.164 df = 12 P <.02

This was not at all surprising when it was noted that leather combat boots were primarily involved in permitting the feet to become wet from external liquids. Furthermore, these boots were grossly inadequate for the temperatures encountered. Since such large numbers of cases claimed their feet were wet with sweat and from melted snow, it was of interest to relate the condition of the feet to the type of bootgear worn at the time of injury. In Tables 65, 66, 67 and 68 White and Negro cases and controls all show similar patterns. Cases wearing the leather combat boot which is not impervious to liquids showed, as was to be expected, a high incidence of wet feet from external seepage (mud or snow) whereas cases wearing the shoepac or insulated rubber boot had a very high percentage of feet wet with sweat. The new insulated rubber combat boot appeared to have produced more sweat than did shoepacs; however, chi square (contingency tables) calculations show these differences not to be significant. In any event it will be recalled from previous tables that the new insulated rubber boot was rarely associated with frostbite despite its high sweat induction. This is readily understood when it is realized that in the new boot sweat could not serve too well as a conductor since the insulation is sealed between impervious rubber layers, whereas in the shoepac the sock and insole, serving as insulators, become saturated with sweat and lose their insulating qualities. The differences between cases and controls noted in Table 63 above were found to be primarily in wetness from external sources. Inspection of Tables 65 to 68 inclusive reveals that these differences were maintained in the race and gear distri-

TABLE 65

RELATION OF CONDITION OF FEET TO TYPE OF FOOTGEAR
WORN BY 326 WHITE CASES OF FROSTBITE OF THE FEET
KOREA, 1951-52

Condition of Feet	Type of Footgear						Total	
	Russet & 2-Buckle		Shoepac		Insulated Rubber Boot			
	No.	%	No.	%	No.	%	No.	%
Dry	31	22.8	47	25.8	1	12.5	79	24.2
Wet with sweat	20	14.7	117	64.3	7	87.5	144	44.2
Wet with mud or snow	77	56.6	9	4.9	0	-	86	26.4
Wet from wading in water	8	5.9	9	4.9	0	-	17	5.2
Total	136	100.0	182	99.9	8	100.0	326	100.0

Chi square = 129.036 df = 6 P <.001

TABLE 66

RELATION OF CONDITION OF FEET TO TYPE OF
FOOTGEAR WORN BY 403 BUNKER-MATE CONTROLS
KOREA, 1951-52

Condition of Feet	Type of Footgear						Total	
	Russet & 2-Buckle		Shoepac		Insulated Rubber Boot			
	No.	%	No.	%	No.	%	No.	%
Dry	32	22.5	59	27.7	8	16.7	99	24.6
Wet with sweat	24	16.9	152	71.4	40	83.3	216	53.6
Wet with mud or snow	82	57.7	1	0.5	0	-	83	20.6
Wet from wading in water	4	2.8	1	0.5	0	-	5	1.2
Total	142	99.9	213	100.1	48	100.0	403	100.0

Chi square = 210.031 df = 6 P <.001

TABLE 67

RELATION OF CONDITION OF FEET TO TYPE OF FOOTGEAR
WORN BY 227 NEGRO CASES OF FROSTBITE OF THE FEET
KOREA, 1951-52

Condition of Feet	Type of Footgear						Total	
	Russet & 2-Buckle		Shoepac		Insulated Rubber Boot			
	No.	%	No.	%	No.	%	No.	%
Dry	35	33.3	34	29.8	1	12.5	70	30.8
Wet with sweat	14	13.3	71	62.3	7	87.5	92	40.5
Wet with mud or snow	51	48.6	7	6.1	0	-	58	25.6
Wet from wading in water	5	4.8	2	1.8	0	-	7	3.1
Total	105	100.0	114	100.0	8	100.0	227	100.0
Chi square = 80.667 df = 6 P <.001								

TABLE 68

RELATION OF CONDITION OF FEET TO TYPE OF FOOTGEAR
WORN BY 37 NEGRO BUNKER-MATE CONTROLS
KOREA, 1951-52

Condition of Feet	Type of Footgear						Total	
	Russet & 2-Buckle		Shoepac		Insulated Rubber Boot			
	No.	%	No.	%	No.	%	No.	%
Dry	10	43.5	1	12.5	0	-	11	29.7
Wet with sweat	6	26.1	7	87.5	6	100.0	19	51.4
Wet with mud or snow	7	30.4	0	-	0	-	7	18.9
Wet from wading in water	0	-	0	-	0	-	0	-
Total	23	100.0	8	100.0	6	100.0	37	100.0
Chi square = 15.874 df = 4 P <.01								

butions (2.2 S.E.) with added emphasis on wetness from wading in water (2.7 S.E.). There were no significant differences between the races but this will be elaborated upon in the race discussion below.

One hundred eighty cases of frostbite of the hands were compared to the bunker-mate controls with respect to the condition of their hands at the time of injury (Table 69). It was obvious that significantly fewer cases than controls had dry hands and a significant excess of cases reported their hands were wet with water. As was done previously for feet, the relationship of the condition of the hands to the severity of injury was calculated. Table 70 shows a highly significant direct relationship between wetness of the hands from external sources and degree of injury i.e. more cases of frostbite of the hands had higher degrees of injury when the hands were wet with external liquids than when dry or wet with sweat.

TABLE 69

COMPARISON OF 180 CASES OF FROSTBITE OF THE HANDS AND 450 BUNKER-MATE CONTROLS WITH RESPECT TO CONDITION OF HANDS AT TIME OF INJURY KOREA, 1951-52

Condition of Hands	Cases		Controls	
	No.	%	No.	%
Dry	110	61.1	372	82.7
Wet from sweat	23	12.8	50	11.1
Wet from water	45	25.0	28	6.2
Wet from other liquids	2	1.1	0	—
Total	180	100.0	450	100.0
Chi square = 51.701 df = 3 P <.001				

TABLE 70

RELATION OF DEGREE OF INJURY TO CONDITION OF HANDS AT TIME OF INJURY AMONG 180 CASES OF FROSTBITE OF THE HANDS
KOREA, 1951-52

Condition of Hands	Degree of Injury - Hands								Total	
	First		Second		Third		Fourth			
	No.	%	No.	%	No.	%	No.	%	No.	%
Dry	60	71.4	42	56.0	5	41.7	3	33.3	110	61.1
Wet from sweat	13	15.5	9	12.0	1	8.3	0	—	23	12.8
Wet from water	10	11.9	24	32.0	6	50.0	5	55.6	45	25.0
Wet from other liquids	1	1.2	0	—	0	—	1	11.1	2	1.1
Total	84	100.0	75	100.0	12	100.0	9	100.0	180	100.0

Chi square = 27.891 df = 9 P <.001

In Table 69 it will be noted that wetness from external liquids contributed significantly to the production of frostbite of the hands. This was again emphasized when the data were redistributed according to race and type of handgear worn (Tables 71 and 72). Added emphasis was noted on wetness from external liquids when the hand case wore no gloves.

N. Foot Hygiene and Change of Footwear

No special studies on foot hygiene were conducted in Korea in 1951-52. Foot hygiene was however part of personal hygiene observations in the pre-exposure study, but these observations were conducted almost exclusively on individuals who were not frostbitten. Though racial differences were noted (Appendix Table 36), data for only 120 cases who were observed in the hospital under highly favorable environmental circumstances were available for comparison. Furthermore bias could not be considered as having

RESTRICTED
Security Information

TABLE 71

COMPARISON OF 104 WHITE CASES OF FROSTBITE OF THE HANDS AND 398 WHITE BUNKER-MATE CONTROLS WITH RESPECT TO TYPE OF HANDWEAR WORN AND CONDITION OF HANDS AT TIME OF INJURY KOREA, 1951-52

Handwear Worn	Condition of Hands							
	White Cases				White Controls			
	Dry	Wet With Sweat	Wet With Water	Wet With Other Liquids	Dry	Wet With Sweat	Wet With Water	Wet With Other Liquids
Mitten, complete	22	7	4	0	147	35	9	0
Mitten, shell	1	0	0	0	1	0	0	0
Mitten, insert	3	0	2	0	4	0	0	0
Glove, complete	28	4	8	0	156	12	16	0
Glove, shell	0	0	0	0	2	0	0	0
Glove, insert	2	1	3	0	5	0	2	0
No gloves	5	1	11	2	9	0	0	0
Total	61	13	28	2	324	47	27	0

TABLE 72

COMPARISON OF 73 NEGRO CASES OF FROSTBITE OF THE HANDS AND 36 NEGRO BUNKER-MATE CONTROLS WITH RESPECT TO TYPE OF HANDWEAR WORN AND CONDITION OF HANDS AT TIME OF INJURY KOREA, 1951-52

Handwear Worn	Condition of Hands							
	Negro Cases				Negro Controls			
	Dry	Wet With Sweat	Wet With Water	Wet With Other Liquids	Dry	Wet With Sweat	Wet With Water	Wet With Other Liquids
Mitten, complete	14	2	6	0	14	0	0	0
Mitten, shell	1	0	0	0	1	0	0	0
Mitten, insert	0	0	1	0	0	0	0	0
Glove, complete	22	6	5	0	19	1	0	0
Glove, shell	1	0	0	0	0	0	0	0
Glove, insert	1	0	2	0	1	0	0	0
No gloves	9	0	3	0	0	0	0	0
Total	48	8	17	0	35	1	0	0

RESTRICTED
Security Information

been completely lacking and the reliability of this data was thus low. No studies were conducted on foot inspection practices among units.

Fairly adequate data were available for one aspect of the foot hygiene problem, namely change of footwear. Data were collected on the average interval of sock change, interval between last change of socks and onset of frostbite and average interval of insole change. "Change" in this latter item did not imply a turnover for new or fresh insoles but rather a change to dry ones.

It is fairly obvious that socks and insoles wet with sweat or external liquids are relatively good conductors of heat and can thus be conducive to cold injury. The effect of sock and insole change upon the incidence of frostbite may only be speculated upon without elaborate factor analysis of all the data. A clue to whether this factor played a significant role in frostbite may be derived by comparing the average sock and insole change intervals among cases with those among bunker-mate controls. In Table 73 a comparison is presented between cases and controls in relation to the average (customary) interval between changes of socks but no significant difference was found. (Though a significant difference was found between White and Negroes relative to average change of socks these data were not significantly different from the respective control data by race as noted in Appendix Table 23. Hence consolidation of the data in Table 73 was considered valid). Neither was there any apparent relationship between the interval of average sock change and the degree of injury (Table 74) as might have been expected if sock change played an obvious r

TABLE 73

RESTRICTED
Security Information

COMPARISON OF 678 CASES OF FROSTBITE AND 454 CONTROLS WITH RESPECT TO AVERAGE CHANGE OF SOCKS PRIOR TO COLD INJURY
KOREA, 1951-52

Average Sock Change	Cases		Controls	
	No.	%	No.	%
Every day	454	67.0	337	74.2
Every other day	141	20.8	73	16.1
Every third day	47	6.9	19	4.2
Every fourth day	14	2.1	9	2.0
Every fifth day	5	0.7	1	0.2
Every sixth day	17	2.5	8	1.8
Every seventh day	0	-	7	1.5
Total	678	100.0	454	100.0
Mean	1.6 days		1.5 days	
S.D.	± 1.05		± 1.14	
t = 1.493 P >.10				

in the Korean winter of 1951-52.

Similarly cases and controls wearing shoepacs were compared in relation to the average (customary) change of insoles (Table 75). A definitely significant excess of cases who revealed the fact that they did not change their insoles at all up to the time of injury indicated that lack of adequate insole change could have contributed to the frostbite incidence. No relationship, on the other hand, could be found between the interval of average change of insoles and the degree of injury (Table 76). Comparisons of the mean intervals in days for the several degrees of injury revealed no significant differences.

RESTRICTED
Security Information

TABLE 74

RELATION OF DEGREE OF INJURY TO INTERVAL OF AVERAGE CHANGE OF SOCKS AMONG 558 CASES OF FROSTBITE OF THE FEET KOREA, 1951-52

Average Change of Socks	Degree of Injury - Feet								Total	
	First		Second		Third		Fourth			
	No.	%	No.	%	No.	%	No.	%	No.	%
Every day	154	64.7	114	67.5	84	67.2	16	61.5	368	65.9
Every other day	53	22.3	34	20.1	27	21.6	3	11.5	117	21.0
Every third day	16	6.7	10	5.9	7	5.6	4	15.4	37	6.6
Every fourth day	7	2.9	3	1.8	1	0.8	2	7.7	13	2.3
Every fifth day	1	0.4	3	1.8	0	-	1	3.8	5	0.9
Every sixth day	7	2.9	5	3.0	6	4.8	0	-	18	3.2
Total	238	99.9	169	100.1	125	100.0	26	99.9	558	99.9

Chi square = 18.484 df = 15 P >.20

TABLE 75

COMPARISON OF 365 CASES OF FROSTBITE AND 232 CONTROLS (WEARING SHOEPACS) WITH RESPECT TO INTERVAL OF AVERAGE CHANGE OF INSOLES
KOREA, 1951-52

Average Insole Change	Cases No.	Cases %	Controls No.	Controls %
Every day	242	66.3	173	74.6
Every other day	56	15.3	34	14.7
Every third day	12	3.2	7	3.0
Every fourth day	0	-	2	0.8
Every fifth day	0	-	0	-
Every sixth day	8	2.2	6	2.6
No change	47	12.9	10	4.3
Total	365	99.9	232	100.0
Chi square = 15.568 df = 5 P <.01				

Since no significant differences between cases and controls were found when the average interval of sock change was compared, the interval between last sock change and date of frostbite was compared and a significant excess was found among cases with an interval of over 5 days since last change of socks (Table 77). The actual number of cases involved however was small and mitigated the importance of this factor in the incidence of frostbite in Korea during the winter of 1951-52, especially since a majority of cases changed socks less than one day prior to frostbite. This latter was corroborated by inquiries in front-line units where it was learned that company commanders frequently ordered fresh sock changes before units went out on patrols.

Further analysis was made of th[illegible]rval between last change of socks and the time of frostbite in relation to the condition

RESTRICTED
Security Information

TABLE 76

RELATION OF DEGREE OF INJURY TO INTERVAL OF AVERAGE CHANGE OF INSOLES
AMONG 270 CASES OF FROSTBITE OF THE FEET WEARING SHOEPACS
KOREA, 1951-52

Average Change of Insoles	Degree of Injury - Feet								Total	
	First		Second		Third		Fourth			
	No.	%	No.	%	No.	%	No.	%	No.	%
Every day	87	77.7	74	74.7	44	80.0	2	50.0	207	76.7
Every other day	19	17.0	17	17.2	8	14.5	1	25.0	45	16.7
Every third day	5	4.5	5	5.1	1	1.8	0	-	11	4.1
Every fourth day	0	-	0	-	0	-	0	-	0	-
Every fifth day	0	-	0	-	0	-	0	-	7	2.6
Every sixth day	1	0.9	3	3.0	2	3.6	1	25.0	7	2.6
Total	112	100.1	99	100.0	55	99.9	4	100.0	270	100.1
Mean (Days)	1.3		1.4		1.4		2.5		1.4	
S.D.	± 0.69		± 0.98		± 1.00		± 2.75		± 0.91	

RESTRICTED
Security Information

RESTRICTED
Security Information

TABLE 77

COMPARISON OF 692 CASES OF FROSTBITE AND 453 CONTROLS
WITH RESPECT TO INTERVAL BETWEEN LAST CHANGE OF
SOCKS AND DATE OF FROSTBITE
KOREA, 1951-52

Last Change of Socks	Cases		Controls	
	No.	%	No.	%
< - 1 day	447	64.6	255	56.3
1 - 2 days	169	24.4	150	33.1
2 - 3 days	31	4.5	33	7.3
3 - 4 days	17	2.5	9	2.0
4 - 5 days	2	0.3	1	0.2
> 5 days	26	3.8	5	1.1
Total	692	100.1	453	100.0

Chi square = 21.797 df = 5 P <.001

of the feet at the time of injury in an effort to determine whether this interval bore any relationship to such condition, i.e. whether the length of the interval could have influenced the condition of the feet or been influenced by it. In Table 78 comparisons indicated that a significant difference existed between cases (and controls) whose feet were wet by external liquids and those whose feet were either dry or wet with sweat, with the former category showing longer intervals. This finding did not indicate that prolongation of the interval influenced the condition of the feet for it was obvious that though postponing sock change could have been conducive to increased wetness either from sweat or from external liquid by prolonged seepage, no difference in the sock change interval was seen between the cases whose feet were dry and those whose feet were wet with sweat. It was necessary then to look elsewhere for the reason behind the significantly higher

interval since last change of socks for cases and controls whose feet were wet with external liquids. From the discussion of the role of extra footwear carried by the rifleman in frostbite incidence above, it will be remembered that the lack of extra footwear for changing did bear a relationship to the incidence of frostbite. A clue was derived from this data in that a significantly larger (2.5 S.E.) percentage of cases whose feet were wet with external liquids did not carry any extra footwear to change (Table 78a). This probably contributed to the longer interval since last change of socks.

TABLE 78

COMPARISON OF INTERVAL BETWEEN LAST SOCK CHANGE AND ONSET OF FROSTBITE AMONG 544 FOOT CASES AND 397 CONTROLS (EXCLUSIVE OF THOSE WEARING INSULATED RUBBER BOOTS) WITH RESPECT TO CONDITION OF FEET
KOREA, 1951-52

Condition of Feet	Interval Between Last Sock Change and Frostbite					
	Cases			Controls		
	No.	Mean (days)	S.D.	No.	Mean (days)	S.D.
Dry	150	1.0	± 0.86	104	1.0	± 0.96
Wet with sweat	222	1.0	± 1.05	192	1.0	± 0.80
Wet with external liquids	172	1.5	± 1.47	101	1.7	± 0.75

O. Command Leadership and Morale

No satisfactory measures of command leadership and morale as psychosocial attributes have been presented in the literature. Much has been written concerning the role of good leadership in producing high morale, yet not only the elements which make up good leadership, but even those which constitute morale have defied even quasi-quantitative description. To find some measures of

RESTRICTED
Security Information

TABLE 78a

PERCENTAGE CARRYING NO EXTRA FOOTWEAR FOR THE SEVERAL CONDITIONS OF THE FEET AMONG 544 CASES AT THE TIME OF FROSTBITE
KOREA, 1951-52

Condition of the feet	No.	No. carrying no extra footwear	%	S. D. Diff. %	No. of S.E.
Dry	150	35	23.3	4.53	0.6
Wet with sweat	222	58	26.1	4.12	
Wet with external liquids	172	60	34.9		2.5

leadership and morale would undoubtedly lead to the solution of the role of these attributes in cold injury.

It has been said that units with high morale "have lower rates for venereal disease, fewer court martials and a minimum of accidents" (6). Hypothesizing that if cold injury was inversely related to morale and leadership and if nonbattle injuries were also inversely related to these attributes, units with high nonbattle injury rates should also show high cold injury rates. The former rates were calculated for each regiment (excluding cold injuries) on a monthly basis and averaged for the 5-month period. These were then correlated by Spearman's rank-order method with the mean frostbite rates for the period for all the regiments (Table 79). No significant correlation was found. The value of 0.278 for rho was quite unreliable because the number of paired observations was small and the 1% fiducial limits ranged from -0.291 to +0.706 with the true coefficient falling anywhere within these limits. Product-moment correlations between nonbattle injury and cold injury rates were calculated utilizing data for regiments only when they were in the line as well as irrespective of the time spent in the lines.

RESTRICTED
Security Information

TABLE 79

COMPARISON OF MEAN MONTHLY COLD INJURY RATES WITH MEAN MONTHLY NONBATTLE INJURY RATES AMONG 21 UNITED STATES REGIMENTS KOREA, 1951-52

Division and Regiment	Mean Nonbattle Injury Rate	Mean Cold Injury Rate
2nd Inf. Div.		
9 Reg.	162.0 *(6)	2.7 (19)
23 Reg.	145.6 (10)	2.3 (20)
38 Reg.	125.5 (16)	5.7 (17)
3rd Inf. Div.		
7 Reg.	172.5 (3)	32.6 (5)
15 Reg.	98.2 (20)	14.7 (13)
65 Reg.	159.9 (7)	29.2 (7)
7th Inf. Div.		
17 Reg.	150.7 (9)	87.3 (1)
31 Reg.	162.9 (5)	12.6 (14.5)
32 Reg.	205.3 (1)	24.9 (9)
24th Inf. Div.		
5 Reg.	142.8 (11)	30.5 (6)
19 Reg.	171.7 (4)	10.2 (16)
21 Reg.	132.1 (14)	28.5 (8)
25th Inf. Div.		
14 Reg.	135.4 (12)	3.7 (18)
27 Reg.	93.5 (21)	0.6 (21)
35 Reg.	122.1 (19)	19.2 (10)
40th Inf. Div.		
160 Reg.	127.3 (15)	37.4 (4)
223 Reg.	181.4 (2)	74.6 (2)
224 Reg.	122.8 (18)	12.6 (14.5)
45th Inf. Div.		
179 Reg.	159.7 (8)	18.9 (11)
180 Reg.	133.1 (13)	38.0 (3)
279 Reg.	125.2 (17)	17.9 (12)

*Numbers in parenthesis indicate rank in rank-order correlation. rho = 0.278 P >.05

but no significant correlation could be established (-0.004 and +0.076 respectively.) Thus the data failed to establish a relationship between nonbattle injury rates (as a reflection of command responsibility and morale) and cold injury rates.

Military disciplinary records (as an index of morale) also were compared in an attempt to establish differences between cases and controls. The pre-exposure study yielded information on 119 frostbite cases and 1,535 controls (Table 80). No significant difference between the two groups could be found. Thus disciplinary records did not provide a measure of morale in relation to frostbite.

Rotational policies were uniform and liberal in Korea during the winter of 1951-52. Most divisions utilized the system of rotating a single regiment into reserve at a time. One or two divisions utilized a battalion reserve system of rotation in which all three regiments of the division were in the line and one battalion from each regiment in reserve. Thus such uniformity, possible only in a static defense situation, obviated unit comparisons of cold injury rates with relation to rotation and possible variations in morale. Rotation to the Zone of Interior w standardized on a point system and front-line rifleman could expect such rotation after approximately one year of service in forward areas. Thus adequate rest, a static front and rotation to the United States a relatively early attainable goal undoubtedly contributed to good morale. No measurement of morale was achieved and its quantitative role in frostbite remained indeterminate.

P. Combat Experience

TABLE 80

COMPARISON OF 119 CASES OF FROSTBITE AND 1535 PRE-EXPOSURE CONTROLS WITH RESPECT TO DISCIPLINARY RECORD PRIOR TO COLD INJURY
KOREA, 1951-52

Disciplinary Record	Cases		Controls	
	No.	%	No.	%
None	97	81.5	1304	84.9
Company punishment	7	5.9	94	6.1
Summary court-martial	9	7.6	83	5.4
Special court-martial	4	3.4	25	1.6
General court-martial	0	-	4	0.3
More than one company punish.	0	-	10	0.6
More than one summary c. m.	1	0.8	7	0.4
More than one special c. m.	0	-	2	0.1
More than 3 of above items	1	0.8	6	0.4
Total	119	100.0	1535	99.8
Chi square = 5.112 df = 8 P >.70				

The ability to cope with the problems of survival and to achieve a relative measure of comfort in inclement weather and under combat conditions is the result not only of classroom and field training but also of repeated disciplined applications of the mechanics of survival and comfort under these conditions. Troops in Korea during the winter of 1951-52 were for the most part replacements for troops who fought in cold weather the previous winter. Table 81 indicates that more than one-half of the cases and controls were in Korea for no longer than 3 months and that but 0.6% of the cases and 8.4% of the controls were in Korea for longer than 8 months. This would definitely indicate that the bulk of the troops in 1951-52 had not been engaged in winter combat during 1950-51. No significant difference was found between cases and controls in

respect to length of time spent in Korea (t = 1.053 P >.20). From data collected in the pre-exposure study it was found, furthermore, that only 2.9% of the front-line replacements had seen combat previous to Korea (World War II).

TABLE 81

COMPARISON OF 694 CASES OF FROSTBITE AND 454 CONTROLS WITH RESPECT TO THE TIME SPENT IN KOREA PRIOR TO COLD INJURY
KOREA, 1951-52

Days in Korea	Cases		Controls	
	No.	%	No.	%
0- 30	108	15.6	85	18.7
31- 60	138	19.9	74	16.3
61- 90	109	15.7	75	16.5
91-120	77	11.1	45	9.9
121-150	71	10.2	17	3.7
151-180	46	6.6	44	9.7
181-210	25	3.6	38	8.4
211-240	116	16.7	38	8.4
Over 240	4	0.6	38	8.4
Total	694	100.0	454	100.0
Mean	105.6 days		110.5 days	
S.D.	± 72.64		± 79.82	
t = 1.053 P >.20				

The number of days spent in actual combat was smaller because of the static front which provided opportunity for frequent rotation of regiments into reserve. In Table 82 the frostbite cases and epidemiologic controls are distributed according to number of days in combat. No significant difference existed between cases and controls irrespective of race, but the small number of days spent

in actual combat by the majority of both groups was striking.

From these three groups of data it may be concluded that combat experience for the United States troops in Korea was relatively minimal especially in winter warfare. This relative lack of experience was not a major factor in the incidence of frostbite since control data were virtually identical. If this inexperience affected the production of frostbite, the incidence contributed by this factor was obscured or hidden by the other more obvious factors, e.g. inadequate gear, immobility in combat etc.

TABLE 82

COMPARISON OF 679 CASES OF FROSTBITE AND 454 CONTROLS WITH RESPECT TO DAYS IN COMBAT KOREA, 1951-52

Days in Combat	Cases		Controls	
	No.	%	No.	%
0 - 15	192	28.3	113	24.9
16 - 30	125	18.4	84	18.5
31 - 45	65	9.6	59	13.0
46 - 60	51	7.5	32	7.1
61 - 75	35	5.2	19	4.2
76 - 90	39	5.7	27	6.0
91 - 105	32	4.7	21	4.6
106 - 120	34	5.0	37	8.2
More than 120	106	15.6	61	13.5
Total	679	100.0	453	100.0
Chi square = 9.941 df = 8 P >.20				

Q. Cold Weather Training

The effectiveness of cold weather training probably depends upon both an environmental and a host factor. The environmental factor may be represented by the external experience as, for

example, the amount of didactic material presented to the individual, the length of time spent in winter maneuvers and, certainly, length of time in winter combat. The host factor may include the elements of receptivity and utilization of such experience which in turn is conditioned by such attributes as intelligence, morale, self-discipline and the will to survive.

During the 1951-52 studies an attempt was made in the pre-exposure study to assess the amount of training received per soldier for cold weather warfare. The data collected are summarized in Table 83. Differences were apparent between frostbite cases interviewed in the hospital and pre-exposure controls questioned in replacement centers. The same shortcomings are inherent in this analysis as were noted in the World War II study by Whayne (6). A more precise measurement of this factor and its role in the production of frostbite will depend upon a survey of adequately kept records on the individual soldier relative to the number of hours of instruction by lectures and films and the length of time spent in cold weather operations and cold weather combat.

In general, the findings revealed the cases to have had much less cold weather training than did the controls, which result however is not completely devoid of emotional tendency, on the part of the cases, to assign external blame for their injury. Thus definite conclusions cannot be drawn from this data.

IX. HOST FACTORS

In any discussion of the agent-host relationship in disease or trauma, the interdependence of these two broad categories cannot be overlooked. External factors in the environment which modify the action of the agent

TABLE 83

RESTRICTED
Security Information

SUMMARY OF AMOUNT OF COLD WEATHER TRAINING BY TYPE FOR 120 FROSTBITE CASES AND 1628 PRE-EXPOSURE CONTROLS KOREA, 1951-52

Type of Cold Weather Training	Means**	
	Cases	Controls
Lectures	1.2	3.5
Films	1.2	2.5
Clothing demonstrations	1.2	1.9
Cold weather operations	—*	0.4

* Data lacking
** Number of lectures, films or demonstrations attended

either favorably or unfavorably can also modify host factors. As examples of this interdependence in cold injury there can be cited the influence of the stress of combat activity upon the posture of the infantryman, his ability to move, his emotional response, sweating, the influence of command leadership on morale and the will to survive and survive comfortably. In the subsequent discussion of host factors this interdependence should be borne in mind.

Furthermore, just as environmental factors are occasionally attributes which lend themselves only to quasi-quantitative mensuration, so host factors are frequently of this type and hence difficult to assess except by comparisons of incidence of the factor between test and control groups. In the ensuing discussion, wherever measurable, analysis of host factors will be presented quantitatively.

A. Age

Age has never been implicated as influencing individual susceptibility to cold injury. Although the very young with their relatively unstable cardiovascular systems and the older individ-

RESTRICTED
Security Information

uals with their reduced adaptability to vascular stress might be more susceptible to cold injury, nevertheless the age groups found in the armed forces and exposed to the rigors of front-line winter combat are usually well within these extremes. Furthermore, the screening of draft selectees and the subsequent rejection of the physically unfit undoubtedly operate in fair measure against the existence of a significant proportion of relatively more susceptible individuals. In Italy no relationship between age and trenchfoot could be established utilizing hospitalized controls (10). On the Western Front of Europe in 1944-45 no evidence of the influence of age on trenchfoot (6) and in Korea in 1950-51 no relationship between age and frostbite (7) were found although both these studies lacked controls. The age distribution of the Korean cases of 1950-51 was notably lower than that observed in the European Theater of Operation (85.7% and 35% respectively under 25 years of age).

In 1951-52 the observed age distribution of cases of frostbite in Korea was not unlike that for 1950-51, with 90.2% of the cases under 25 years of age and a range from 17 to 38 years (Table 84). These differences, i.e. among the experiences of the ETO, Korea 1950-51 and Korea 1951-52, can readily be accounted for by the differences in draft needs and policies. In the ETO the manpower demands of World War II brought into the armed forces older individuals, more married men and fathers than did the manpower demands of the Korean conflict. Furthermore, the first year of Korean action saw somewhat older soldiers in the line than the winter of 1951-52 since initially troops came from Japan and were serving

TABLE 84

RESTRICTED
Security Information

COMPARISON OF AGE DISTRIBUTIONS OF 703 CASES OF FROSTBITE, 455 BUNKER-MATE CONTROLS AND 1626 PRE-EXPOSURE CONTROLS KOREA, 1951-52

Age in Years	Cases		Bunker-Mate Controls		Pre-exposure Controls	
	No.	%	No.	%	No.	%
15-19	115	16.3	48	10.7	302	18.6
20-24	519	73.9	356	78.3	1179	72.5
25-29	56	8.0	44	9.6	121	7.3
30-34	10	1.4	4	0.8	18	1.1
35-39	3	0.3	3	0.6	4	0.3
40-44	0	—	0	—	1	0.1
45-49	0	—	0	—	0	—
50-54	0	—	0	—	1	0.1
Total	703	99.9	455	99.9	1626	100.0
Mean Age	21.9		22.5		21.7	
S.D.	± 2.55		± 2.47		± 2.63	

under longer rotation policies than troops in 1951-52.

The mean age of the 1951-52 frostbite cases was 21.9 years. Bunker-mate controls had a mean age of 22.5 years, a statistically significant difference, but of no apparent functional or physiologic importance. This difference was in part due to the omission of Marines and two other divisions with their significantly younger troops from the control sample (Appendix Table 5) and in part due to the relatively smaller proportion of Negroes (whose average age was lower) among the controls. The age distribution of the pre-exposure controls was probably more representative in this regard for the front as a whole and revealed

RESTRICTED
Security Information

no significant difference from the cases. Thus age appears definitely not to have played a role in frostbite in Korea during 1951-52.

Age differences might influence severity of injury, i.e. younger individuals might show more severe frostbite because of less experience in winter combat. The data were further analyzed with respect to age, degree of injury, race and site. In Table 85 no age-severity trend was noted for White cases of frostbite of the feet although Negro cases showed an inverse relationship between degree of injury and age. The difference in mean age between first and fourth degrees of frostbite in Negroes was statistically significant. Similar trends were not apparent for either White or Negro hand cases.

B. Rank

Earlier (Table 5) it was shown that frostbite had a high selectivity for front-line riflemen. It was expected that the rank distribution among frostbite cases would show a preponderance of lower ranks. Table 86 presents the comparisons among cases, bunker-mate controls, company strength and the Eighth Army in respect to rank. There was a highly significant excess of privates and privates first class among cases over that expected from the distributions in the Eighth Army, in rifle companies and among the bunker-mate controls. Thus, since front-line riflemen were predominantly of lower ranks, these data reiterated their selectivity in frostbite by greater chance of exposure.

A higher rank was very frequently the reflection of a combination of factors such as experience, aptitude, intelligence and

RESTRICTED
Security Information

TABLE 85

COMPARISON OF MEAN AGES FOR WHITE AND NEGRO FOOT AND HAND CASES OF FROSTBITE WITH RESPECT TO DEGREE OF INJURY
KOREA, 1951-52

Degree of Injury	Foot Cases				Hand Cases			
	White (N=336)		Negro (N=237)		White (N=56)		Negro (N=44)	
	Mean Age	S.D.	Mean Age	S.D.	Mean Age	S.D.	Mean Age	S.D.
First	21.6	± 2.34	21.9	± 2.47	23.7	± 3.51	21.1	± 1.45
Second	22.2	± 2.52	21.5	± 2.03	21.7	± 2.84	22.1	± 2.08
Third	22.2	± 3.48	21.2	± 2.13	26.0	± -	20.7	± 1.73
Fourth	21.6	± 1.90	20.6	± 1.83	22.8	± 1.11	22.0	± -
Total	21.9	± 2.62	21.5	± 2.23	22.6	± 3.06	21.7	± 1.85

TABLE 86

COMPARISON OF DISTRIBUTIONS BY RANK OF 707 FROSTBITE CASES, 455 BUNKER-MATE CONTROLS AND THE UNITED STATES EIGHTH ARMY
KOREA, 1951-52

Rank	Cases		Controls		Co. Strength*	Eighth Army
	No.	%	No.	%	%	%
Pvt.	231	32.7	58	12.8	50.5	21.7
Pfc.	279	39.5	168	36.9		31.9
Cpl.	122	17.3	113	24.8	25.2	23.7
Sgt.	69	9.8	113	24.8	21.0	16.4
Co. Gd. Off.	6	0.8	3	0.7	3.3	5.2
Fld. Gd. Off.	0	-	0	-	-	1.1
Total	707	100.1	455	100.0	100.0	100.0

Cases vs Controls:	Chi square = 92.945	df = 4	P <.001
Cases vs Eighth Army:	Chi square = 118.461	df = 5	P <.001
Controls vs Eighth Army:	Chi square = 63.287	df = 5	P <.001
Controls vs Co. Strength:	Chi square = 8.109	df = 4	P >.05
Cases vs Co. Strength:	Chi square = 39.468	df = 4	P <.001

* Personnel of Infantry Rifle Company - T/O and E 7-17N, 15 Nov. 1950

RESTRICTED
Security Information

leadership. These attributes should rationally operate toward much lower attack rates among sergeants. In Table 86 it will be seen that though a significant number of sergeants were frostbitten, the proportion was distinctly less (9.9%) than the number of sergeants found in a rifle company (21.0%). Though this difference was partially due to relatively more sheltered positions for the upper ranks of enlisted men, the bunker-mate control sample which included only line sergeants revealed that they were in identical situations with the corporals and privates, e.g. pinned down on patrols, wading streams, holding line positions in unheated bunkers etc. Since only approximately 10% of the sergeants in a rifle company are not in the line (clerks etc.), this still leaves 19% of the rifle companies' strength represented by line (platoon and squad) sergeants who have equal or approximately equal chance of exposure. By another calculation involving the cases in line companies only and correcting for the strength by rank in such companies, it was found that privates and corporals combined had 3.1 times the attack rate which sergeants (platoon and squad) experienced (Table 86a).

The question next arose whether this rank was less frequently immobilized despite the relationship in time and location for the control and frostbitten sergeants. This is a logical query, for one frequently visualizes the sergeant of a platoon or squad, on a patrol, as moving quickly among his men appraising the situation and giving orders. Actually during the Korean experience of 1951-52 this concept did not hold. From data in Appendix Table 8, chi square contingency tables were constructed to show the relation-

TABLE 86a

RESTRICTED
Security Information

FROSTBITE ATTACK RATES FOR COMPANIES
ACCORDING TO RANK
KOREA, 1951-52

Rank	Cases	Strength in Companies	Rate/1000
Pvt. and Pfc.	410	25452	16.11
Corporal	87	12701	6.85
Combined	497	38153	13.03
Sgt. and Sfc.	40	9526	4.20
Total	537	47679	11.26

ship between rank and activity among cases and controls for all situations whether on patrol or in bunkers. Table 87 reveals no significant difference in intensity of activity between privates and corporals as a group and sergeants (plus six company grade officers) who were frostbitten. In similar fashion Table 88 reveals no difference in intensity of activity between lower and higher ranks among controls. To determine whether the significant difference in intensity of activity observed between cases and controls in Table 44 was maintained in a rank distribution, the data were tested according to intensity of activity among cases and controls for lower ranks (Table 89) and for higher ranks (Table 90). The same significant differences were found between cases and controls for each level of rank. It was clear that the sergeants involved in frostbite were no more mobile than the frostbite cases of lower rank. The inference, then, was that factors other than mobility and relative risk of exposure were operative.

RESTRICTED
Security Information

RESTRICTED
Security Information

TABLE 87

COMPARISON OF LOWER RANKS WITH HIGHER RANKS
IN REGARD TO INTENSITY OF ACTIVITY DURING
EXPOSURE AMONG 700 CASES OF FROSTBITE
KOREA, 1951-52

Intensity of Activity	Group I * Ranks	Group II ** Ranks	Total
Light	453	56	509
Heavy	173	18	191
Total	626	74	700
Chi square = 0.366 df = 1 P >.50			

TABLE 88

COMPARISON OF LOWER RANKS WITH HIGHER RANKS
IN REGARD TO INTENSITY OF ACTIVITY DURING
EXPOSURE AMONG 455 BUNKER-MATE CONTROLS
KOREA, 1951-52

Intensity of Activity	Group I * Ranks	Group II ** Ranks	Total
Light	186	65	251
Heavy	153	51	204
Total	339	116	455
Chi square = 0.048 df = 1 P >.80			

* Group I Ranks = Pvt. thru Corporal
** Group II Ranks = Sgt. thru Field Grade Officer

RESTRICTED
Security Information

TABLE 89

COMPARISON BETWEEN 626 LOWER RANK CASES OF FROSTBITE AND 339 LOWER RANK CONTROLS WITH RESPECT TO INTENSITY OF ACTIVITY AT TIME OF EXPOSURE KOREA, 1951-52

Intensity of Activity	Cases	Controls	Total
Light	453 (414)*	186	639
Heavy	173	153	326
Total	626	339	965
Chi square = 30.096 df = 1 P <.001			

* Expected number

TABLE 90

COMPARISON BETWEEN 74 HIGHER RANK CASES OF FROSTBITE AND 116 HIGHER RANK CONTROLS WITH RESPECT TO INTENSITY OF ACTIVITY KOREA, 1951-52

Intensity of Activity	Cases	Controls	Total
Light	56 (47)*	65	121
Heavy	18	51	69
Total	74	116	190
Chi square = 7.536 df = 1 P <.01			

* Expected number

Among the factors contributing to this lower incidence among sergeants was race. Later, it will be shown that Negroes were

more liable to attack by frostbite than Whites. Since there were fewer Negro sergeants in the front line than White sergeants (3.6% and 11.9% respectively), it was reasonable to assume that the contribution to frostbite incidence by Negro sergeants was thereby relatively lower. In other words had Negro sergeants been present in the same proportion among Negro troops as there were White sergeants in proportion to White troops there would have been more cases of frostbite among sergeants as a whole. Whereas 6.1% of the sergeants among pre-exposure controls were Negroes, 18.2% of the sergeants among the cases were Negroes (Table 91).

Another factor probably of prime importance, though less measurable, was the attribute of experience. This might be measured by the time spent in Korea and by the length of time in combat. The line sergeants who were frostbitten showed no significant difference in mean time spent in Korea from the lower rank enlisted men (106.5 days and 105.7 days respectively). The nonfrostbitten sergeants were in Korea significantly longer (126.5 days) than the nonfrostbitten lower rank men (103.4 days). The nonfrostbitten sergeants as a group had the advantage of approximately one more month in Korea than did the lower grades. In terms of days in combat which also is an expression of experience, no significant difference was found between frostbitten sergeants (62.9 days) and frostbitten lower grades (52.9 days). On the other hand, among controls who were not frostbitten the sergeants showed a significantly greater length of time in combat than did the lower grades. However, no significant difference was noted in the mean number of days in combat between frostbitten and nonfrostbitten sergeants.

RESTRICTED
Security Information

TABLE 91

COMPARISON OF UPPER AND LOWER GRADES OF ENLISTED MEN AMONG CASES OF FROSTBITE AND CONTROLS (NONFROSTBITTEN) WITH RESPECT TO SEVERAL SELECTED FACTORS
KOREA, 1951-52

Factor	Cases				Controls			
	Sgts.	Pvt. Pfc. Cpl.	Test of Significance	P	Sgts.	Pvt. Pfc. Cpl.	Test of Significance	P
Race (% Negro)	18.2	44.1	$t = 4.047$	<.001	6.1	16.8	$t = 4.367$	<.001
Climatic region (% South)	80.0	80.5	* $\chi^2 = 0.027$	>.80	58.5	67.3	$\chi^2 = 2.555$	>.10
Previous cold injury (%)	25.6	19.0	$\chi^2 = 1.022$	>.30	10.5	11.4	$\chi^2 = 0.053$	>.80
Days in Korea (mean)	106.5	105.7	$t = 1.154$	>.20	126.5	103.4	$t = 2.140$	<.05
Days in combat (mean)	62.9	50.6	$t = 1.471$	>.10	64.3	49.4	$t = 2.732$	<.01
Days in combat without rest (mean)	16.2	15.8	$t = 0.219$	>.80	12.3	11.3	$t = 0.942$	>.30
Footgear	-	-	$\chi^2 = 1.502$	>.95	-	-	$\chi^2 = 4.683$	>.30
Sockgear	-	-	$\chi^2 = 3.980$	>.50	-	-	$\chi^2 = 2.026$	>.80
Condition of feet	-	-	$\chi^2 = 3.095$	>.50	-	-	$\chi^2 = 4.809$	>.30
Last change of socks (days)	1.6	1.6	$t = 0.125$	>.90	1.5	1.6	$t = 0.063$	>.90

* χ^2 = Chi square

RESTRICTED
Security Information

This factor probably does not influence the disparities in attack rate by rank.

Other factors such as previous cold injury among the several ranks, climatic region of origin, bootgear, sockgear and condition of the feet were tested in similar fashion and found noncontributory to the difference in attack rates between lower and higher grades of line infantrymen (Table 91). The obvious differences in incidence of previous cold injury, climatic region of origin and days in combat without rest between cases and controls irrespective of rank will be discussed later in more detail. The differences relative to bootgear, sockgear, condition of the feet and interval since last change of socks between cases and controls irrespective of rank have been discussed previously.

By exclusion of these pertinent factors and by the elicitation of some evidence of greater experience among higher grades, the impression was gained, but by no means proven, that the attributes leading to promotion to higher grades such as dependability, reliability, leadership, responsibility and familiarity with "things military" may well operate in producing a lower rate of frostbite among sergeants even though they were exposed identically with lower grade enlisted men. It is certainly not inconceivable that a sergeant, who coaxes, chides, cajoles or orders his men to change their socks, attend to cleansing of their feet whenever possible, to keep moving the toes and fingers as much as possible even when pinned down by enemy fire and to wear proper gear for the current climatic conditions, will rarely neglect to do these things for himself especially when he not only recognizes their need but must

also set an example for his men. These calculations are presented not so much to elabor rank differences in attack rates but to illustrate the type of approach which may be useful in ultimately assessing the role of attributes of this type.

It was further postulated that the factors operating in producing a lower attack rate among the higher ranks would also tend to reduce the incidence of very severe injuries among them. This, however, was not borne out in separate analyses of foot and hand cases according to rank and degree of injury (Tables 92 and 93).

C. Previous Cold Injury

Although at least one observer (10) has felt that previous exposure does not influence susceptibility, the clinical impression gained in the European Theater revealed that previous trenchfoot predisposed the patient to subsequent injury of this type. Very little evidence in this regard has been documented but the study of Toone and Williams (11) tended to show the hazard of re-exposing previous cases of trenchfoot. Some of these cases in the Italian Campaign later were frostbitten but no specific comparisons were presented for this type of injury. During the Korean conflict in 1950-51, 14.9% of the admissions to the Osaka Army Hospital revealed bona fide histories of previous cold injury (7). Unfortunately no information of this type for nonfrostbitten men was available. There appears to exist little data on the role of previous cold injury with reference to frostbite in the literature.

With the interviewing of bunker-mate and pre-exposure control subjects in the Korean winter of 1951-52, valuable data on previous cold injury were obtained. Both cases and controls were carefully

RESTRICTED
Security Information

TABLE 92

RELATION OF DEGREE OF INJURY TO RANK AMONG
581 CASES OF FROSTBITE OF THE FEET
KOREA, 1951-52

Rank	Degree of Injury - Feet								Total	
	First		Second		Third		Fourth			
	No.	%	No.	%	No.	%	No.	%	No.	%
Pvt.	73	29.6	67	38.1	48	36.6	16	59.3	204	35.1
Pfc.	101	40.9	68	38.6	57	43.5	10	37.0	236	40.6
Cpl.	46	18.6	26	14.8	14	10.7	1	3.7	87	15.0
Sgt.	25	10.1	12	6.8	12	9.2	0	-	49	8.4
Co. Gd. Off.	2	0.8	3	1.7	0	-	0	-	5	0.8
Total	247	100.0	176	100.0	131	100.0	27	100.0	581	99.9

Chi square = 20.461 df = 12 P >.05

TABLE 93

RELATION OF DEGREE OF INJURY TO RANK AMONG
182 CASES OF FROSTBITE OF THE HANDS
KOREA, 1951-52

Rank	Degree of Injury - Hands								Total	
	First		Second		Third		Fourth			
	No.	%	No.	%	No.	%	No.	%	No.	%
Pvt.	26	30.6	19	25.3	4	33.3	4	40.0	53	29.1
Pfc.	33	38.8	24	32.0	5	41.7	3	30.0	65	35.7
Cpl.	16	18.8	18	24.0	3	25.0	3	30.0	40	22.0
Sgt.	9	10.6	13	17.3	0	-	0	-	22	12.1
Co. Gd. Off.	1	1.2	1	1.3	0	-	0	-	2	1.1
Total	85	100.0	75	99.9	12	100.0	10	100.0	182	100.0

Chi square = 7.329 df = 12 P >.80

RESTRICTED
Security Information

interrogated with respect to the symptoms and signs of previous cold injury. Questioning was directed to elicit specific responses which would leave no doubt as to the injury and included questions as to the environment, the activity, the conditions and duration of exposure, the need for medical care and the length of disability. For example, mere coldness or numbness of the part was not accepted as evidence of previous injury, but a history of swelling with desquamation or vesicle formation along with the numbness had to be elicited. Trenchfoot and chilblains were included as cold injury.

A statistically significant difference between cases and controls was found in the 1951-52 experience in respect to previous cold injury (Table 94). The cases showed 8.4% more instances of previous cold injury than did the bunker-mate controls. This difference became even more impressive when, utilizing the percentage of previous cold injury among the controls as a projection to the Eighth Army as a whole, attack rates for the army population previously cold injured and previously <u>not</u> cold injured were calculated and compared. The troops with a history of previous cold injury revealed an attack rate of 5.03 per 1,000 whereas those without such a history had an attack rate of 2.58 per 1,000. Further comparison with the pre-exposure controls revealed a similar significant difference (Table 95). Of interest was the fact that but 1.8% of the pre-exposure controls were previously frostbitten in Korea. This reflected both rotation policy and the policy of reassignment to other duties after cold injury. In addition 0.6% were injured by cold in Germany and 0.1% in Ireland.

D. Previous Illness

TABLE 94

COMPARISON OF 664 CASES OF FROSTBITE AND 447 BUNKER-MATE CONTROLS WITH RESPECT TO HISTORY OF PREVIOUS COLD INJURY KOREA, 1951-52

History of Previous Cold Injury	Cases		Controls	
	No.	%	No.	%
None	535	80.6	397	88.8
Frostbite	125	18.8	38	8.5
Trenchfoot	1	0.2	2	0.4
Chilblains	3	0.5	10	2.2
Total	664	100.1	447	99.9
Chi square = 29.544 df = 3 P <.001				

TABLE 95

COMPARISON OF 664 FROSTBITE CASES TO 1596 PRE-EXPOSURE CONTROLS WITH RESPECT TO HISTORY OF PREVIOUS COLD INJURY KOREA, 1951-52

History of Cold Injury	Pre-Exposure Controls	Frostbite Cases	Total
None	1390	535	1925
Cold Injury	206	129 (98)*	335
Total	1596	664	2260
Chi square = 15.790 df = 1 P <.001			

* Expected number

RESTRICTED
Security Information

TABLE 96

DISTRIBUTION OF 716 CASES OF FROSTBITE AND 445 BUNKER-MATE CONTROLS ACCORDING TO HISTORY OF PREVIOUS ILLNESS
KOREA, 1951-52

History of Previous Illness	Cases		Controls	
	No.	%	No.	%
Frequent fevers	9	1.3	4	0.9
Pneumonia	94	13.1	80	18.0
Jaundice	1	0.1	12	2.7
Malaria	32	4.5	24	5.4
Raynauds'	3	0.4	1	0.2
Hematuria	2	0.3	10	2.2
Syphilis	12	1.7	3	0.7
None	563	78.6	311	69.9
Total	716	100.0	445	100.0

Chi square = 36.726 df = 8 P <.001

Although inquiry into previous illness of cases and controls was designed to elicit the several conditions which might affect the level of the cold hemagglutinins, Whayne's reference to the possible influence of infectious disease on susceptibility to cold injury led to an evaluation of the possible relationship between such previous illnesses and frostbite. Table 96 presents a comparison of selected illnesses among cases and bunker-mate controls. Although a significant difference existed between the two distributions, the apparent excess among the cases was for a history of syphilis. Subsequent analyses (see "Race" section below) revealed this difference to reside primarily and significantly among the Negro frostbite cases. When it is recalled that the venereal disease rates among the general population are higher for the Negro, the impres-

RESTRICTED
Security Information

RESTRICTED
Security Information

TABLE 97

RELATION OF DEGREE OF INJURY OF 589 CASES OF FROSTBITE OF THE FEET TO THE HISTORY OF PREVIOUS ILLNESS
KOREA, 1951-52

Previous Illness	Degree of Injury - Feet								Total	
	First		Second		Third		Fourth			
	No.	%	No.	%	No.	%	No.	%	No.	%
None	189	74.4	143	80.8	107	81.7	21	77.8	460	78.1
Fevers	4	1.6	1	0.6	2	1.5	1	3.7	8	1.4
Pneumonia	41	16.1	21	11.9	16	12.2	3	11.1	81	13.8
Jaundice	1	0.4	0	-	0	-	0	-	1	0.2
Malaria	15	5.9	9	5.1	2	1.5	1	3.7	27	4.6
Raynauds'	2	0.8	0	-	0	-	0	-	2	0.3
Hematuria	0	-	0	-	1	0.8	0	-	1	0.2
Syphilis	2	0.8	3	1.7	3	2.3	1	3.7	9	1.5
Total	254	100.0	177	100.1	131	100.0	27	100.0	589	100.1

Chi square = 19.512 df = 21 P >.50

sion is gained that this relationship may be fortuitous, i.e. based on other and possibly numerous factors common to both frostbite and syphilis, rather than a direct physiologic relationship between the two. No further clue to such a relationship was derived from an analysis of the data on previous illnesses by degree of injury (Table 97).

E. Condition of Patient at Time of Injury

It is obvious that physical stress of disease producing fatigue and wounds producing shock and unconsciousness may well predispose to frostbite. In the winter of 1950-51 (7) only a small number of patients were recorded as having been ill or wounded as a direct or indirect cause of frostbite. It was mentioned, however, that this data did not take into account the many frostbite cases with severe battle w nds hospitalized elsewhere than in the Cold Injury

RESTRICTED
Security Information

TABLE 98

RESTRICTED
Security Information

COMPARISON OF 702 FROSTBITE CASES AND 437 BUNKER-MATE CONTROLS ACCORDING TO PHYSICAL CONDITION AT TIME OF INJURY AMONG THE CASES KOREA, 1951-52

Condition of Patient	Cases No.	Cases %	Controls No.	Controls %
Healthy	677	96.4	430	98.4
Ill	13	1.9	7	1.6
Injury directly responsible for condition	5	0.7	0	-
Injury indirectly responsible for condition	7	1.0	0	-
Total	702	100.0	437	100.0

Section of the Osaka Army Hospital. Such frostbite could well have been the result of such wounds.

Unlike the situation which prevails in active offense and especially in active defense or in retrograde movement, the patrolling and line holding activities of static defense are not as conducive to casualty rates with attendant cold injury of the wounded who cannot be brought in to shelter and medical care immediately. In this respect the Korean conflict of 1951-52 differed from the previous winter. Very few cold injuries occurred as a direct or indirect result of battle wounds (Table 98).

F. Nutritional Status

Detailed studies on vitamin C and protein levels among frostbite cases and controls are discussed in other sections of this report (Sections XII and XV). No surveys of actual consumption of food could be undertaken among front-line troops prior to injury. Some

relatively minor observations were made, however, and these dealt primarily with type of meals consumed and the interval between consumption of last meal and onset of frostbite.

For the most part an attempt was made to serve two hot meals daily along the line. Usually these were breakfast and supper. Often the so-called "hot meal" was cold upon reaching the forward bunkers. The third meal was most frequently C Ration. Table 99 presents a comparison of the types of meals consumed before frostbite by cases and controls. If anything, the controls ate less than a full C Ration meal or individual food pack more often than the cases and tended to eat fewer hot meals (B Ration). However, of greater import was the number consuming hot meals and complete C Rations and the rare occasions when the meal was eaten more than 24 hours prior to frostbite (Table 100). This was indeed quite different from the situation prevailing in the previous winter when the lines were extremely mobile and retrograde action prevailed. More than 80% of the cases ate their previous meal less than 12 hours prior to onset of frostbite. On the average the cases ate approximately 7.5 hours prior to frostbite and the controls 8.5 hours. Though statistically significant no physiologic significance could be attached to the difference. No difference in this interval was noted between hand and foot cases, but for both hand and foot cases fourth degree injuries showed a distinct and significantly longer interval which may reflect longer exposures rather than a causal relationship (Table 101).

No exact weight determinations were obtained on cases and controls either before or after frostbite. Responses to the query on "weight

TABLE 99

COMPARISON OF 695 CASES OF FROSTBITE AND 452 BUNKER-MATE CONTROLS WITH RESPECT TO TYPE OF MEAL LAST EATEN BEFORE FROSTBITE KOREA, 1951-52

Meal Type	Cases		Controls	
	No.	%	No.	%
C Ration	280	40.3	209	46.2
B Ration	383	55.1	205	45.4
Individual food pack	6	0.9	0	-
Native food	5	0.7	0	-
Less than C Ration or individual food pack	21	3.0	38	8.4
Total	695	100.0	452	100.0
Chi square = 30.099 df = 4 P <.001				

change since coming to Korea" proved to be more nearly an index of "self-pity" than a reliable index of weight change. The majority of the cases claimed losses from one to 11 or more pounds whereas the majority of the controls claimed no change in weight (Table 102). Since these data were based on the patients own estimate and occasionally involved reference to his own subjective sensation or fit of his clothes, further interpretation would be speculative.

G. Fatigue

Fatigue may operate as a factor contributing to cold injury by physical and mental exhaustion which may progress to such a degree that movement of the extremities, let alone change of socks, is an effort. Furthermore, mental weariness itself may be conducive to apathy which in turn leads to neglect of all acts except those

RESTRICTED
Security Information

TABLE 100

COMPARISON OF 677 CASES OF FROSTBITE AND 454 BUNKER-MATE CONTROLS WITH RESPECT TO INTERVAL BETWEEN LAST MEAL AND ONSET OF COLD INJURY KOREA, 1951-52

Hours	Cases		Controls	
	No.	%	No.	%
0 - 6	344	50.8	186	41.0
7 - 12	232	34.3	186	41.0
13 - 18	69	10.2	58	12.8
19 - 24	26	3.8	21	4.6
25 - 48	5	0.7	1	0.2
49 - 72	1	0.1	1	0.2
73 - 96	0	-	0	-
97 - 120	0	-	1	0.2
Total	677	99.9	454	100.0
Mean S.D.	7.54 ± 6.01		8.55 ± 7.52	
$t = 2.395$ $P < .05$				

TABLE 101

COMPARISON OF MEAN INTERVALS SINCE LAST MEAL BEFORE FROSTBITE BY SITE AND DEGREE OF INJURY IN 553 FEET AND 172 HAND CASES OF FROSTBITE KOREA, 1951-52

Degree of Injury	Feet			Hands		
	No. of Cases	Mean Interval Since Last Meal in Hours	S.D.	No. of Cases	Mean Interval Since Last Meal in Hours	S.D.
First	239	7.9	± 6.97	81	7.2	± 5.38
Second	169	7.1	± 5.25	72	8.2	± 5.72
Third	120	7.1	± 4.66	11	7.5	± 5.29
Fourth	25	10.4	± 8.22	8	10.9	± 5.50
Total	553	7.6	± 6.12	172	7.5	± 5.53
$t = 0.484$ $P > .60$						

RESTRICTED
Security Information

TABLE 102

COMPARISON OF WEIGHT CHANGE AMONG 473 CASES OF FROST-BITE AND 454 CONTROLS
KOREA, 1951-52

Weight Change	Cases		Controls	
	No.	%	No.	%
No change	170	35.9	236	52.2
1- 5 lbs. less	84	17.8	66	14.6
6-10 lbs. less	110	23.3	54	11.9
11 or more lbs. less	65	13.7	49	10.8
1- 5 lbs. more	22	4.7	18	4.0
6-10 lbs. more	13	2.7	20	4.4
11 or more lbs. more	9	1.9	9	2.0
Total	473	100.0	452	99.9
Chi square = 35.564 df = 6 P <.001				

vital to survival. Fatigue is not measured by duration of stress alone but by the intensity of the stress as well. As such, this factor becomes difficult to assess especially when several units are engaged in combat activity of varying intensity which itself defies accurate measurement. Since combat activity in the Korean Theater in 1951-52 was relatively more stable than in the preceding winter and confined to the tasks of patrolling and line holding in a static defense situation, the duration of stress became a component more nearly correlative to the factor of fatigue.

Duration of stress was measured by the number of days spent in combat without rest. Both cases and controls were interrogated relative to this factor utilizing any withdrawal from the line for periods of longer than half a day as the end of the interval. Because of the combat situation shower points were placed quite close to the front lines. Rotation to the showers frequently provided

several hours rest and refreshment for the troops. Only where shower points broke down and troops were turned back to the lines immediately upon arrival was combat without rest deemed unbroken. The situation in this regard was quite unlike the experience during the previous winter and in the European Theater in 1944-45. Whereas in the European experience survey data revealed that 70% of the trenchfoot cases had been in combat without rest for 8 days or more (6), in the Korean winter of 1951-52 only 50.8% were in this category (Table 103), reflecting the relatively better chance for rest among troops in Korea in 1951-52.

In Table 103 comparison of front-line battalion cases and controls revealed that the cases were in combat without rest for a significantly longer period indicating that fatigue may have played a role. The number of cases who failed to obtain rest for periods of a month or more was rather surprising in view of rotation policies, but may, in part, reflect the last drives in Operation Killer in September and October of 1951. The controls revealed much fewer instances of longer intervals without rest. In view of the fact demonstrated above, that cases and controls did not differ significantly in the length of time spent in Korea and in combat areas, the only alternative remaining is that the cases probably did not avail themselves of opportunities for rest (e.g. to shower points).

H. Tobacco

The use of tobacco as a factor in the production of frostbite unfortunately has been expressed all too often on the basis of theoretical considerations rather than on controlled observation. Since smoking has been shown to produce a fall in peripheral skin

RESTRICTED
Security Information

TABLE 103

COMPARISON OF 517 CASES OF FROSTBITE
AND 407 CONTROLS WITH RESPECT TO
DAYS IN COMBAT WITHOUT REST
KOREA, 1951-52

Days in Combat Without Rest	Cases* No.	Cases* %	Controls* No.	Controls* %
0 - 4	143	27.7	73	17.9
5 - 9	111	21.5	102	25.1
10 - 14	64	12.4	131	32.2
15 - 19	54	10.4	69	17.0
20 - 24	26	5.0	11	2.7
25 - 29	18	3.5	5	1.2
30 - 34	34	6.6	8	2.0
35 - 39	11	2.1	2	0.5
Over 39	56	10.8	6	1.5
Total	517	100.0	407	100.1
Chi square = 112.474 df = 8 P <.001				

* From front-line battalions only.

temperature by peripheral vasoconstriction, the assumption has been made that this would be productive of cold injury among heavy smokers. This could not be demonstrated for the Korean cold casualties of 1950-51 (7) and in the winter of 1951-52 an almost identical proportion of cases and controls (18.5% and 18.8% respectively) did not smoke at all. Table 104 presents this data for 1951-52. To the contrary there was a significantly greater number of cigarettes consumed among the controls who smoked. The data from the pre-exposure study reaffirmed this latter finding, i.e. more controls smoked pipes (8.0%) than did cases (3.3%), controls smoked more cigars than did the cases and even tobacco chewing was more frequent among controls (5.4%) than among cases (0.8%). Thus it

RESTRICTED
Security Information

TABLE 104

RESTRICTED
Security Information

COMPARISON OF 691 CASES OF FROSTBITE AND 442 BUNKER-MATE CONTROLS WITH RESPECT TO DAILY AMOUNT OF SMOKING
KOREA, 1951-52

Cigarettes Per Day	Cases		Controls	
	No.	%	No.	%
None	128	18.5	83	18.8
1/2 pack	211	30.5	66	14.9
1 pack	241	34.9	179	40.5
1-1/2 packs	54	7.8	54	12.2
2 packs	46	6.7	44	10.0
Over 2 packs	11	1.6	16	3.6
Total	691	100.1	442	100.0

Chi square = 42.877 df = 5 P <.001

can be stated with safety that no association existed between excessive smoking and frostbite. If anything, the association favored the nonfrostbitten control.

Comparisons of the number of cigarettes smoked by foot cases with that by hand cases revealed no significant difference and no consistent differences between degrees of injury could be found (Table 105).

I. Inherent Constitutional Factors

The hunt for some simple and universally applicable test to screen individuals susceptible to cold has been the task of many investigators of cold injury. The difficulties encountered are probably due to problems of definition and measurement of the so-called inherent constitutional factors upon which are superimposed the multiple factors of the environment.

Individual susceptibility has been alluded to earlier in the

RESTRICTED
Security Information

TABLE 105

RELATION OF MEAN DAILY AMOUNT OF CIGARETTES SMOKED TO DEGREE OF INJURY AMONG 567 CASES OF FROSTBITE OF THE FEET AND 178 CASES OF FROSTBITE OF THE HANDS
KOREA, 1951-52

Degree of Injury	Feet			Hands		
	No. of Cases	Mean No. of Packs Smoked	S.D.	No. of Cases	Mean No. of Packs Smoked	S.D.
First	242	0.9	± 0.60	83	0.8	± 0.55
Second	172	0.8	± 0.60	74	0.7	± 0.58
Third	127	0.7	± 0.52	12	0.8	± 0.61
Fourth	26	0.7	± 0.52	9	0.9	± 0.56
Total	567	0.8	± 0.58	178	0.7	± 0.56
$t = 1.225$ $P > .20$						

discussions on previous cold injury. However, the number of instances of chilblains and Raynaud's disease elicited during the bunker-mate and pre-exposure control surveys were exceedingly small as would be expected because of preinduction screening. Only three cases (0.5%) of chilblains were found among the 716 frostbite cases, 10 instances (2.2%) among the 455 bunker-mate controls (Table 94) and 14 (1.0%) among 1,596 pre-exposure controls. Because of such small numbers no intergroup comparisons were made. No instances of Raynaud's or other vascular disease were found among these groups. Peripheral vascular abnormalities, other than previous damage by frostbite or trenchfoot were not an important factor in the frostbite experience in Korea during 1951-52.

Gahrbandt (12) felt that the vagotonic or bradycardic individual is very susceptible to cold and set a pulse rate of less than 68 per minute as indicative of such susceptibility. Resting pulse

rates obtained on a sample of 118 frostbite cases and for 1,577 pre-exposure controls tended to support this theory. Table 106 presents the findings of this study. There will be noted a distinctly lower mean pulse rate for the cases than for the controls. Whereas only 7.6% of the controls had a pulse rate of less than 70, 23.7% of the sample of cases were found to be in this category. Furthermore the range among cases was much narrower (64-92) than among controls (60-128). This comparison might be criticized on the grounds that the pulse rates on the cases were obtained in the relatively peaceful environment of a hospital in Japan, whereas those on the controls were obtained in the battle zone. This criticism was not deemed to be significant however since the pre-exposure data were obtained primarily from troops in regimental or division reserve and only a very small percentage from new replacements. The ideal comparison would have been between pre-exposure subjects subsequently not frostbitten and pre-exposure subjects subsequently frostbitten for whom pulse rates were obtained under identical conditions in the field. Unfortunately there were only two pre-exposure subjects of the 1,628 examined who became frostbite cases, a situation dictated by chance on the basis of this total number of pre-exposure subjects.

J. Psychosocial Factors

The host complex includes certain factors which, though vital to any problem of stress, may not always be readily evaluated. Morale and motivation of the group already have been discussed as a component of the environment though morale of the individual and morale of the group are interdependent. An attempt was made to

TABLE 106

RESTRICTED
Security Information

COMPARISON OF RESTING PULSE RATES AMONG 118
FROSTBITE CASES AND 1577 PRE-EXPOSURE CONTROLS
KOREA, 1951-52

Pulse Rate (Beats Per Minute)	Cases No.	Cases %	Controls No.	Controls %
60-69	28	23.7	120	7.6
70-79	44	37.3	292	18.5
80-89	42	35.6	505	32.0
90-99	4	3.4	403	25.6
100-109	0	-	199	12.6
110-119	0	-	40	2.5
120-129	0	-	18	1.1
Total	118	100.0	1577	99.9
Mean Rate	75.3		86.8	
S.D.	± 7.91		± 12.24	
t = 14.491 P <.001				

evaluate these factors by indirect means. Other factors are however somewhat more measurable and these include education and aptitude.

Certainly the receptivity of the soldier to training and his learning from experience in combat is directly modified by his intelligence and education. Though the urge or appreciation of the need for survival may not be based upon educational achievement or intelligence level, nevertheless his ability to survive is certainly modified thereby.

Some measurement of these factors was undertaken but no differences were found between cases and controls. In Table 107 a comparison of school grade completed by a sample of 114 frost-

TABLE 107

COMPARISON OF SCHOOL GRADE COMPLETED BY 114 FROSTBITE CASES AND 1343 PRE-EXPOSURE CONTROLS KOREA, 1951-52

School Grade Completed	Cases No.	Cases %	Pre-Exposure Controls No.	Pre-Exposure Controls %
2	0	-	2	0.1
3	0	-	4	0.3
4	0	-	7	0.5
5	0	-	8	0.6
6	3	2.6	37	2.8
7	3	2.6	86	6.4
8	14	12.3	221	16.5
9	13	11.4	137	10.2
10	24	21.1	202	15.0
11	15	13.2	137	10.2
12	36	31.6	415	30.9
13	1	0.9	40	3.0
14	2	1.8	38	2.8
15	1	0.9	6	0.4
16	2	1.8	2	0.1
17	0	-	1	0.1
Total	114	100.2	1343	99.9
Mean	10.5		10.1	
S.D.	± 1.94		± 2.14	
t = 1.753 P >.05				

bite cases and 1,343 pre-exposure controls is presented. Both distributions revealed a bimodality which may be explained by the relatively more frequent termination of schooling at the eighth or tenth grade levels. The difference between the two groups represented but a fraction of a grade and was not statistically significant. Both groups showed a similar proportion of instances

of college years completed.

The Army General Classification Test scores (hereinafter referred to as AGCT scores) intended to reveal aptitudes, knowledges and skills were compared for cases and pre-exposure controls. Aptitude Areas I and III were utilized separately in all calculations. Area I involved the battery of Reading Vocabulary Tests, Arithmetic Reasoning Test and Pattern Analysis Test. Area III included only the first two named. These were considered to represent basic aptitudes and learning achievements so that relative indices might be available for assessing ability to grasp and to apply such aptitudes to cold weather combat. Since the distributions of scores for Area III were virtually synonymous with those for Area I for all subgroups (Area I actually contains Area III), such as cases, controls, race and climatic region of origin of the cases and controls, only Area I will be presented in this discussion.* Table 108 indicates the degree of identity between Area I and Area III scores in the AGCT among the several groups. Table 109 presents a comparison of mean AGCT scores for Area I between a sample of the cases and pre-exposure controls. The significant difference, indicating the controls to have higher aptitude and knowledge (in this basic area), must be viewed with some reservation for although the control group was representative of the proportion of Negroes in the Eighth Army, it did not correspond with the percentage among cases. Nor did the sample of cases correspond with the over-all experience. Whereas 41% of the cases were Negroes the sampling

---

* Basic tables and calculations will be found in the Appendix Tables 129 and 130.

TABLE 108

COMPARISON OF AREA I AND AREA III MEAN SCORES IN THE ARMY GENERAL CLASSIFICATION TEST FOR FROSTBITE CASES AND PRE-EXPOSURE CONTROLS BY RACE AND CLIMATIC REGION OF ORIGIN
KOREA, 1951-52

Group	Area I			Area III			t	P
	No.	Mean Score	S.D.	No.	Mean Score	S.D.		
White Cases:								
North*	6	103.5	± 20.04	6	104.7	± 19.98	0.101	>.90
South*	20	89.3	± 17.58	20	88.5	± 18.74	0.131	>.80
White Controls:								
North	347	98.9	± 18.69	424	98.9	± 18.81	0.052	>.90
South	579	92.2	± 16.95	689	91.8	± 18.73	0.399	>.60
Negro Cases:								
North	0	-	-	2	58.5	± 15.00	-	-
South	43	73.9	± 14.33	43	73.8	± 16.40	0.027	>.90
Negro Controls:								
North	10	78.3	± 12.56	10	76.8	± 11.21	0.282	>.70
South	178	70.8	± 12.46	179	70.4	± 13.64	0.326	>.70

* Regions defined in section on "Climatic Region of Origin".

TABLE 109

COMPARISON OF FROSTBITE CASES AND PRE-EXPOSURE CONTROLS WITH RESPECT TO MEAN AGCT SCORES (AREA I)
KOREA, 1951-52

Group	No.	Mean Score	S.D.	t	P
Cases	69	80.9	± 18.11	4.333	<.001
Controls	1114	90.7	± 19.25		

of cases contained 62%. This is quite pertinent for, in Table 108, there was an intimation that great disparities in AGCT scores (Area I) existed between Whites and Negroes and a surplus of Negroes in the sample would thus lower the mean for the frostbite case group. These racial (and climatic region) differences in mean AGCT scores will be discussed below with reference to their contribution to the differences in attack rates for the two races and the climatic regions. Differences in aptitude, skill and knowledge may have been contributory to the differences in cold weather adjustment as manifested by differences in attack rates.

Before dismissing the psychosocial factors, attention is directed to the role which the personality may play in the production of frostbite. In the neuropsychiatric study some evidence was obtained to indicate that the frostbite case tended to be a passive individual. He did not as often exhibit the drive for achievement and prestige as did members of control groups and tended more often to score higher on the hypochondriasis scale. He was, among other things, more often negativistic. These were all trends based on the examination of few cases and controls, but the impressions were provocative, especially when certain other factors supported this picture.

There are recalled such factors as less activity among cases in identical combat situations with controls, relative inattention to the carrying of extra footwear for changing when combat conditions permitted, less smoking among cases (the opposite of the tense, hypertonic chain-smoker) and the claim, by the cases, of greater weight loss in Korea (self-pity?). Thus. conformity with

a picture from two separate approaches, though not at all conclusive, and at best only impressionistic, should at least stimulate further study in this field. Certainly the concept of a "cold-susceptible personality-complex" in relation to stress is not too remote as a psychosocial factor in cold injury.

K. Race

The problem of racial susceptibility to cold injury and specifically frostbite has, to the present time, remained unresolved. The experiences in past wars often have been beclouded by complicating factors which prevented the analysis of the direct effect of race per se or of the complex of race with its ancillary socio-economic attributes. Not only has it been difficult to determine whether racial differences in attack by cold were due to differences in tissue susceptibility, but the very existence of any differences has been subject to question because certain complicating factors have apparently contributed to the racial disparities in overshadowing form. In the Italian Campaign during World War II, the incidence of trenchfoot among Brazilian and Hawaiian troops was cited (6) as evidence, in part, of racial susceptibility. However, Toone and Williams (11) state "that the incidence of trenchfoot among the Brazilian troops, fighting the same battle under identical conditions, but inexperienced in winter warfare, was at least as high as ours of the previous winter and the cases were much more severe." This does not necessarily indicate a racial difference for evidence of greater attack rates among Brazilians was not given. Furthermore, as Whayne (6) points out, newness to combat and inexperience undoubtedly accounted for a part of this record.

The experience of the French with Senegalese troops in World War I is not clear as to racial susceptibility, for elements of training in winter warfare, personal hygiene, differences in cultural background and numerous other factors, well or poorly defined, may have contributed to the overtly high incidence of frostbite in this group. Even the data on the United States Negro in World War II are not strictly comparable to data for the White soldiers. As was pointed out by Whayne, most Negroes were assigned to service organizations and hence could not be considered as having been exposed "identically" with front-line combat troops. The experience of a completely Negro infantry division in Italy also cannot be accepted as having been comparable and serving as evidence of differences in racial susceptibility, for this unit was inexperienced and new to cold weather combat.

A more nearly adequate approach to the problem can be made only if all possible factors of comparability between the White and Negro groups are equalized. In Korea during 1950-51 some suggestion of race disparities in attack rates were noted (7). However, although a Negro regiment "operated in the same area under similar circumstances of environment and combat" along with two other all White regiments, there was no evidence that differences in morale, training, motivation and incentive did not exist between them which could have accounted for the differences in attack rates rather than true racial susceptibility. On the other hand, some evidence for real racial differences existed in this same study. In another regiment Whites and Negroes were admixed (26-41%) and among 167 cases evacuated from this regiment to Osaka,

82.6% were Negroes. This is highly suggestive of a real difference since mixture of the races was often down to squad level, thus holding combat activity, locale, environmental temperatures, morale and leadership factors constant. However there is no evidence that this race difference was true for all the units in the 1950-51 experience since only about half the injuries were evacuated to Osaka Army Hospital.

It was not until the winter 1951-52 that this factor could be studied in relatively more controlled fashion. The application of bunker-mate control studies, the static defense front with its relatively uniform combat activity and the concomitantly greater opportunity to appraise many more factors along the front lines made comparison between the races more favorable. Furthermore, Negroes were utilized as combat troops relatively more uniformly and admixtures were universally down to squad level. Thus the physical and socioeconomic environment along the battle front was deemed comparable for both races. There was little evidence of discrimination observed by the writer or at least any prejudice was at such a low level as to be imperceptible.* Data for all cold injury cases were available since all cases were evacuated to Osaka Army Hospital in 1951-52.

Although actual Negro troop strength in the United States Eighth Army in Korea was 14.4% the over-all percentage of Negro cases of frostbite was 40.6% (Table 3). This disparity was further empha-

---

* Occasionally, squads of riflemen and mortar crews were in charge of Negro corporals and sergeants for whom respect transcended the pure relationship of rank. Bunker-mates were frequently mixed and the relationship lacked elements of discrimination in the face of a common enemy.

sized among the individual combat units (Appendix Table 9). Even in those units where the percentage of Negroes was low the proportion of Negro cases was high.

Further analysis of the data utilizing racial strengths at the several functional levels (Table 110) revealed the same disproportions. For the Eighth Army as a whole, whereas the Whites constituted 85.6% of the strength, their total attack rate (entire period) was 2.10 per 1,000 as opposed to 8.65 per 1,000 for Negroes who represented but 14.4% of the strength. For troops in divisions (distinct from army and corps support) Whites constituted 91% of the strength with an attack rate of 3.97 per 1,000 as compared to Negroes with 9% of the total divisional strength, but an attack rate of 25.91 per 1,000. Calculations at regimental levels revealed Whites to have constituted 90.1% of the total regimental strength and to have had an attack rate of 5.80 per 1,000 while Negroes, representing but 9.9% of the total regimental strength, experienced an attack rate of 35.86 per 1,000. For the Eighth Army the White to Negro ratio was approximately 1 to 4 and at divisional and regimental levels 1 to 6. (The total attack rate ratios among the several echelons, irrespective of race, are noted to be approximately 1 to 2 to 3; a reiteration of the findings in Table 5 above.)

Although the distribution of Negro cases by site of injury was virtually identical to the distribution of the White cases (Table 111), the Negro cases were more frequently of more severe degree than were the White cases for both foot injuries (Table 112) and hand injuries (Table 113).

TABLE 110

COMPARISON OF TOTAL FROSTBITE ATTACK RATES AND RELATIVE RISKS OF ATTACK FOR THE SEVERAL ECHELONS OF THE UNITED STATES EIGHTH ARMY ACCORDING TO RACE KOREA, 1951-52

Race	Percentage			% of 8th Army Racial Strength	% of Division Racial Strengths	Total Attack Rate per 1000 Strength			Relative Risk of Attack		
	In 8th Army	In Div.	In Reg.	In Div.	In Reg.	In 8th Army	In Div.	In Reg.	In 8th Army	In Div.	In Reg.
White	85.6	91.0	90.1	50.1	59.1	2.10	3.97	5.80	1.00	1.00	1.00
Negro	14.4	9.0	9.9	29.6	65.5	8.65	25.91	35.86	4.12	6.53	6.18
Total	100.0	100.0	100.0	47.2	59.7	3.04	5.95	8.78	1.00	1.95	2.85

TABLE 111

DISTRIBUTION OF 690 CASES OF FROSTBITE ACCORDING TO RACE AND SITE OF INJURY
KOREA, 1951-52

Site	Negro		White	
	No.	%	No.	%
One hand	12	4.2	17	4.2
One foot	28	9.9	32	7.9
Both hands	32	11.3	37	9.1
Both feet	177	62.3	256	63.1
One hand - One foot	2	0.7	1	0.2
Both hands - Both feet	23	8.1	34	8.4
One hand - Both feet	5	1.8	11	2.7
One foot - Both hands	1	0.4	4	0.9
Others (ears, nose)	4	1.4	14	3.4
Total	284	100.1	406	99.9
Chi square = 6.619 df = 8 P >.50				

TABLE 112

RACIAL COMPARISON OF DEGREE OF INJURY AMONG 589 CASES OF FROSTBITE OF THE FEET
KOREA, 1951-52

Degree of Injury	White		Negro		Mongolian		Total	
	No.	%	No.	%	No.	%	No.	%
First	164	47.5	87	36.2	3	75.0	254	43.1
Second	109	31.6	68	28.3	0	-	177	30.1
Third	58	16.8	72	30.0	1	25.0	131	22.2
Fourth	14	4.1	13	5.4	0	-	27	4.6
Total	345	100.0	240	99.9	4	100.0	589	100.0
Chi square = 16.413 df = 3 P <.001								

TABLE 113

RACIAL COMPARISON OF DEGREE OF INJURY AMONG 184
CASES OF FROSTBITE OF THE HANDS
KOREA, 1951-52

Degree of Injury	White		Negro		Mongolian		Total	
	No.	%	No.	%	No.	%	No.	%
First	58	54.7	27	36.0	1	33.3	86	46.7
Second	37	34.9	36	48.0	2	66.7	75	40.8
Third	4	3.8	9	12.0	0	-	13	7.1
Fourth	7	6.6	3	4.0	0	-	10	5.4
Total	106	100.0	75	100.0	3	100.0	184	100.0
Chi square = 9.839 df = 3 P <.02								

Do these very obvious and real differences in attack rates and severity of injury denote differences in tissue susceptibility between the races or do they represent differences in cultural background and implied socioeconomic differences with resulting disparity in aptitudes, receptivity of training and experience? Do these differences represent physiologic variations or are they manifestations of a different host-environment relationship?

To attempt an answer to these pertinent questions it was deemed advisable to explore all the attributes or factors for which data were available. Each factor was analyzed with respect to racial incidence and compared with the corresponding control data. The following may serve as an example. Since the length of time the individual spent in combat without rest seemed to be related to the incidence of frostbite, this factor was assessed for racial differences to ascertain whether the racial difference could have been due to an excess of Negro cases with more time on the battle

line. Or, for example, since cases as a whole carried extra footwear less frequently than did controls, did the Negro cases show a significant deficit in this category to account for a higher attack rate among them? A third example, which should suffice to clarify the approach used, involved the factor of previous cold injury. Since previous cold injury for the cases as a whole appeared to predispose to frostbite, could the excess incidence among Negroes be attributed, in part at least, to a chance excess of individuals with previous cold injury among them? These and other factors for which data had been collected were examined in this way and are presented in summary in Table 114*.

1. Mean Age

The Negro cases were found to be 0.4 years younger than the White cases. Though statistically significant, this difference was probably of no physiologic import in this age group. Contributing to this difference was the greater number of sergeants (and hence older age) among White cases which in turn reflected the greater number of White sergeants than Negro sergeants along the front lines as mentioned earlier in the discussion on rank. Aside from physiologic considerations, if age were to be considered a reflection of experience in combat in Korea, the subsequent data in Table 114 tend to reveal the opposite, for the Negro case was found to have been in Korea one month longer on the average than the White case.

* Basic tables for these calculations will be found in Appendix Tables 10 to 37 inclusive.

TABLE 114

SUMMARY OF ANALYSES OF FACTORS TESTED FOR RELATION TO FROSTBITE IN REGARD TO RACE KOREA, 1951-52

Item	Race White	Race Negro	Test of Significance	df	P
Mean age (years)	22.0	21.6	t = 2.352	694	<.02
Rank	+	-	* χ^2 = 29.616	4	<.001
Type of residence	Rural	Urban	χ^2 = 3.321	1	>.05
Days in Korea	93.7	120.9	t = 5.779	681	<.001
Days in combat	46.2	62.6	t = 4.704	670	<.001
Days in combat without rest	16.0	16.6	t = 0.515	656	>.60
Previous cold injury	+	-	χ^2 = 5.413	3	>.10
Previous illness (syphilis)	-	+	χ^2 = 24.486	7	<.001
Smoking (packs)	0.8	0.7	t = 2.752	556	<.01
Hours since last meal before frostbite	7.7	7.9	t = 0.443	661	>.60
Content of last meal	-	+	χ^2 = 4.621	4	>.30
Footgear worn	+	-	χ^2 = 3.120	6	>.70
Extra footwear carried	+	-	χ^2 = 1.420	4	>.80
Average change of socks (days)	1.5	1.7	t = 2.234	552	<.05
Average change of insoles (days)	1.3	1.5	t = 0.892	258	>.30
Last change of socks	1.1	1.2	t = 1.692	563	>.05
Sockgear worn	+	-	χ^2 = 21.050	6	<.01
Sockgear-Footgear Comb: constrictive	+	-	χ^2 = 0.634	3	>.80
Inadequate insulation	-	+	χ^2 = 3.195	4	>.50
Condition of feet (dry)	-	+	χ^2 = 8.163	4	>.05
Handgear worn (gloves)	+	-	χ^2 = 3.949	6	>.50
Condition of hands (dry)	-	+	χ^2 = 1.956	3	>.70
Activity	+	-	χ^2 = 10.170	8	>.20
Average minimum temp. of exposure	11.7°	13.8°	t = 2.150	620	<.02
School grade completed	10.7	10.3	t = 0.911	114	>.30
Personal Hygiene	+	-	χ^2 = 43.905	2	<.001
Duration of exposure (hours)	6.8	6.3	t = 1.246	618	>.20
AGCT score Area I	92.5	73.2	t = 4.584	71	<.001
AGCT score Area III	92.2	73.2	t = 4.186	71	<.001

* χ^2 = chi square

2. Rank

As mentioned above and demonstrated in Table 91, the disparity in rank between Negro and White cases can readily be explained on the basis of fewer Negro sergeants exposed to risk. The actual number of sergeants among White and Negro cases was actually not significantly different from that expected on the basis of percentages of sergeants in the lines (3.6% and 11.9% respectively). Hence rank differences cannot be said to have contributed to the over-all difference in attack rates.

3. Type of Residence

This information was designed to test possibly greater susceptibility to cold among city dwellers. Although the Negro tended to come from urban areas more frequently, the difference from White cases was not significant.

4. Days in Korea and Days in Combat

In each of these items the Negro cases showed significantly longer intervals than the White cases. This was entirely contrary to what would be expected if the greater Negro attack rate were due to relative lack of familiarity with the terrain and climate and to relative lack of combat experience.

5. Days in Combat Without Rest

No difference between White and Negro cases was observed in regard to this factor in fatigue.

6. Previous Cold Injury

Although the Negro cases gave a history of previous cold injury somewhat less frequently than did the White cases, this

difference was not found to be significant.

7. Previous Illness

As was pointed out earlier the difference between the White and Negro cases of frostbite with respect to history of previous illnesses resided almost entirely in the greater number of cases of syphilis among the latter. The significance of this finding in regard to frostbite was not at all clear and may merely reflect the observed concomitant higher incidence of syphilis in this race.

8. Smoking

The Negro cases smoked somewhat less than did the White frostbite cases. Although statistically significant, the difference was rather small and its physiologic (or even psychosocial) significance was highly speculative. If the amount of smoking is at all characteristic of a personality type, as proposed above under psychosocial factors, the Negro would tend to fit this category.

9. Type of Meal Eaten and Interval Before Frostbite

No significant differences were noted between Negro and White cases with respect to the type of meal last eaten before the onset of frostbite and the length of the interval between the meal and the onset of the cold injury. Actually, the Negro cases tended to have a warm meal slightly more often than did the White. Thus these factors were not deemed contributory to the race difference.

10. Footgear Worn at Time of Injury

If the racial difference in attack rate were at least par-

tially due to a proportionately greater number of Negroes wearing improper bootgear, this certainly was not shown, for the Negro cases wore types of gear almost identical to those worn by the White cases.

11. Extra Footwear Carried

Since it was shown earlier that an association existed between the carrying of extra footwear and frostbite, a racial comparison was made but no significant difference between Whites and Negroes could be found. In fact the distributions among the two races were almost identical.

12. Average Change of Socks and Last Change of Socks Before Frostbite

The White cases claimed to have changed their socks on the average once in 1.5 days which was also the frequency noted by the White bunker-mate controls. The Negro cases changed their socks once in 1.7 days as compared to once in 1.5 days for the Negro bunker-mate controls. This would lead one to assume some contribution by this factor to the greater Negro rate. The more pertinent item would appear to be the interval since the last change of socks before frostbite, but in this regard Whites and Negroes were virtually identical.

13. Average Change of Insoles

Here, too, no statistically significant difference was noted between White and Negro cases of frostbite nor were differences observed between the respective cases and controls.

14. Type of Sockgear Worn

Although White cases showed a significantly greater number wearing two pairs of ski socks, the item of sockgear taken by

itself was of little significance. Its role in frostbite production has been described under clothing and the significance of certain constrictive or inadequately insulative combinations noted. In assessing racial differences these combinations must be considered. Though the White cases tended to have more instances of constrictive combinations and the Negro cases more instances of inadequately insulative combinations, no significant differences were found.

15. Condition of the Feet and Hands

Although no statistically significant difference was noted, the Negro cases more frequently had dry feet at the time of frostbite of the feet than did the White cases. This same relationship was noted for the hands among White and Negro cases of frostbite of the hands. Thus for the Negro the condition of the feet and hands was not necessarily more conducive to heat loss than the White. To the contrary, the White cases were at somewhat greater risk in this respect.

16. Handgear Worn

The distributions of type of handgear worn by White and Negro cases of frostbite of the hands were virtually identical. Approximately the same proportion in each race wore inadequate handgear at the time of injury.

17. Activity

Since cases as a whole, irrespective of race, were found to have been relatively less motile than their bunker-mate controls under identical conditions of combat environment, it was of interest to elicit racial differences if they existed. Al-

though the White cases tended to be somewhat more active than the Negro cases this difference was found not to be significant.

18. Average Minimum Temperature During Exposure

A distinct and statistically significant difference in minimum temperatures during exposure was noted for White and Negro cases. The average minimum temperature during exposure was 2.1 degrees (F) higher for the Negro than for the White case. This finding was of interest since it was contrary to the situation which was productive of more frostbite. A finding in the opposite direction could have explained the racial disparity, for if the Negro were exposed by chance to lower temperatures, he should have had more frostbite. The finding of higher temperatures of exposure for Negro cases is especially noteworthy when it is recalled that the Negro not only had an incidence disproportionate to his strength along the battle line but also had a higher incidence of severe injuries. This factor, rather than explaining the racial difference, merely accentuates the disparity. Whatever was operative in producing a greater incidence and severity of frostbite among Negroes must do so by overcoming opposing factors as, for example, higher temperatures, more experience as would be measured by days in combat and somewhat drier hands and feet.

19. Duration of Exposure

Since chance could have dictated a longer mean exposure period for the Negro it was deemed advisable to compare his duration of exposure with that of the White. No significant difference

between the two races could be found in this respect. In fact the White cases seemed to have been exposed somewhat longer than the Negro (6.8 hours and 6.3 hours respectively).

20. Personal Hygiene

This factor has already been mentioned under "Foot Hygiene" above. It should be re-emphasized that the highly significant difference between Whites and Negroes was based upon observations primarily conducted on pre-exposure controls. Even presuming that bias were not involved, the findings among the controls cannot be projected to the cases, for the White cases could have had equally poor hygienic practices and thus infer a relationship to frostbite for the group as a whole rather than contributing to the difference in racial attack rates.

21. School Grade Completed

No significant difference was found between the two races in respect to the number of school grades completed. For purposes of the ensuing discussion, attention is called to the fact that this item does not take quality of education into account.

22. AGCT Scores

A clue of major significance appeared to be the AGCT scores, for a highly significant difference was noted between the Whites and Negroes in Area I and Area III. The difference represented one whole grade* below median value for the Negro and may well indicate a distinct difference in basic aptitude and knowledge. The reasons behind this difference are beyond the scope of this

* Grade IV as compared to Grade III on a five grade scale with Grade I highest and Grade V lowest.

report. It should be remembered that opportunities for education which not only involves total exposure to education, but its quality as well, may be at a lower level for the Negro especially when so many of the cases come from Southern states (see "Climatic Regions" below).

Of importance to the problem was the relationship of these presumably lower aptitudes, skills or levels of knowledge to frostbite. If the low AGCT score denotes less capability to cope with survival and comfort in cold weather combat, this factor should bear a relationship to certain items of training and orientation. Such items include the wearing of proper sock and bootgear combinations, carrying of extra footwear, changing of socks, constant maintenance of mobility under conditions of severe exposure and the execution of measures of good personal hygiene to the extent that combat conditions permit. Almost all of these items revealed no racial differences of significance except for average change of socks which has been discussed above and personal hygiene which was subject to reservation for it was based on control observations only.

This epidemiologic study does not pretend to have explored all the factors which may contribute to the racial difference in attack rates of cold injury, nor does it claim to have exhausted the many facets of the factors studied. Though the observed difference in aptitude scores as measured by the AGCT was a tempting answer, the collateral evidence to support this theory was lacking. One or two related actors tend in fact to be in an opposing direction. This hypothesis cannot, how-

ever, be dismissed for accurate measurements could not be made of certain attributes such as the way the respective groups wore their body clothing (general body cooling), the imposition of self-discipline, the earliest educational backgrounds and personality traits and behavior patterns of the two groups. Survival in cold weather combat may be predicated more upon primitive intelligence than upon cultural and intellectual achievement for existence in combat is at a rather primitive level. Nevertheless these factors appear to be the avenues for future study in delineating contributions to racial differences. Until the psychosocial factors are quantitated or at least more nearly adequately appraised the validity of this hypothesis must be held in abeyance. As a practical measure, however, and recognizing the Negro as being at greater risk, unit commanders responsible for cold weather orientation and training must emphasize the factors of hygiene, mobility and proper wearing of gear to the Negro to a greater degree to overcome this disparity in vulnerability.

The data presented thus far do not refute the possibility of differences in true tissue susceptibility operating in conjunction with the modifying psychosocial factors.

Although no evidence within the framework of this study has been presented in behalf of a tissue susceptibility hypothesis, the lack of significant racial differences among the several factors which should have been influenced by the AGCT scores makes the refutation of such an hypothesis difficult. Its consideration is tempting when there is also recalled the

inordinately high rate among the Ethiopians, although factors of combat experience, cold weather training and hygiene may have contributed materially despite their acquaintance with cold weather in the mountains of Ethiopia. Of some interest in the support of a tissue susceptibility hypothesis are the observations in the monograph of Kristian Stray (13). Norwegian ski troops in winter maneuvers were studied carefully by this author who found that dark individuals tended to develop frostbite of the ears and face more often than blonde individuals when exposed to virtually identical circumstances. Although statistical tests performed by the author showed no significant difference, trends were apparent and the severity of the lesions appeared to have been greater and to have occurred earlier in the dark individuals.

L. Climatic Region of Origin

Acclimatization to cold has become the subject of a voluminous literature. The ability of certain races indigenous to cold regions to adjust or adapt to the extremes of their environment has been the topic of discussions by explorers and physiologists. The confusion in terminology has likewise grown apace so that it is deemed relevant to redefine acclimatization and accustomization. The dictionary defines acclimatization as "habituation to a climate not native to the individual". Best usage has predicated physiologic changes in the organism as criteria of acclimatization. The compromising addition of clothing as one proceeds from the tropics to the artic is not acclimatization but an adaptation to environmental stress. However, the use of fewer layers of clothing as

one continues to live in the cold as described by Blair (14) and the increased performance efficiency may represent true physiologic acclimatization. Adolph (15) claimed acclimatization in animals and cited increases in mean resting oxygen consumption as physiologic evidence of such acclimatization, but this author denies acclimatization in man. A summary of physiologic evidences tending toward acclimatization in man has been reviewed by Kark (16).

Accustomization does not involve physiologic changes but rather behavioral pattern changes - a "learning-to-live-with-the-cold" as it were. A Sudanese soldier transported to a subartic environment and given gloves might not remember to put his gloves on at first but would soon reach for them to keep his hands warm. A lesser contrast may be represented by an inexperienced artic explorer who soon learns to wear the necessary number of layers of clothing in -40° F. cold.

The evidence for acclimatization on the basis of initially high peaking of incidence with the first waves of cold weather in the Korean experience (8) was rather tenuous and has been mentioned briefly in this report. Since it was difficult to separate the influences of lack of adequate footgear and combat activity in a quantitatively subtractive fashion, it was virtually impossible to say that a residual effect remained which was due to lack of acclimatization among a greater number of susceptibles at the outset of the season. The hypothesis on the other hand cannot be refuted for the same reason. The severity of injury would be significantly greater at the outset and then decline if, all other

factors being constant, acclimatization processes were at work. Although from Figure 2, presented earlier, the November percentage of third and fourth degree injuries was not significantly greater than those in December, the difference from those in February was marked (31.3% as compared to 16.1% respectively) and statistically significant (3.6 S.E.). This finding was complicated by the progressively increasing issue of the new insulated rubber combat boot which was discussed above. Thus the search for greater evidence of acclimatization had to proceed in other directions.

The question naturally arises whether troops originating from northern climates are more acclimatized (or at least accustomized) to cold than are troops from southern climates. In 1950-51, Orr and Fainer (7) presented incidence data on the basis of geographical origin of 464 frostbite cases. They divided the United States into four regions according to the average minimum temperatures of the respective states and found a greater percentage of the sample to have come from the warmer states. Unfortunately, no data of this type was available for a cross section of the front-line troops who were not injured by cold. Thus, the values presented could have reflected a greater number of troops in Eighth Army from these southern regions.

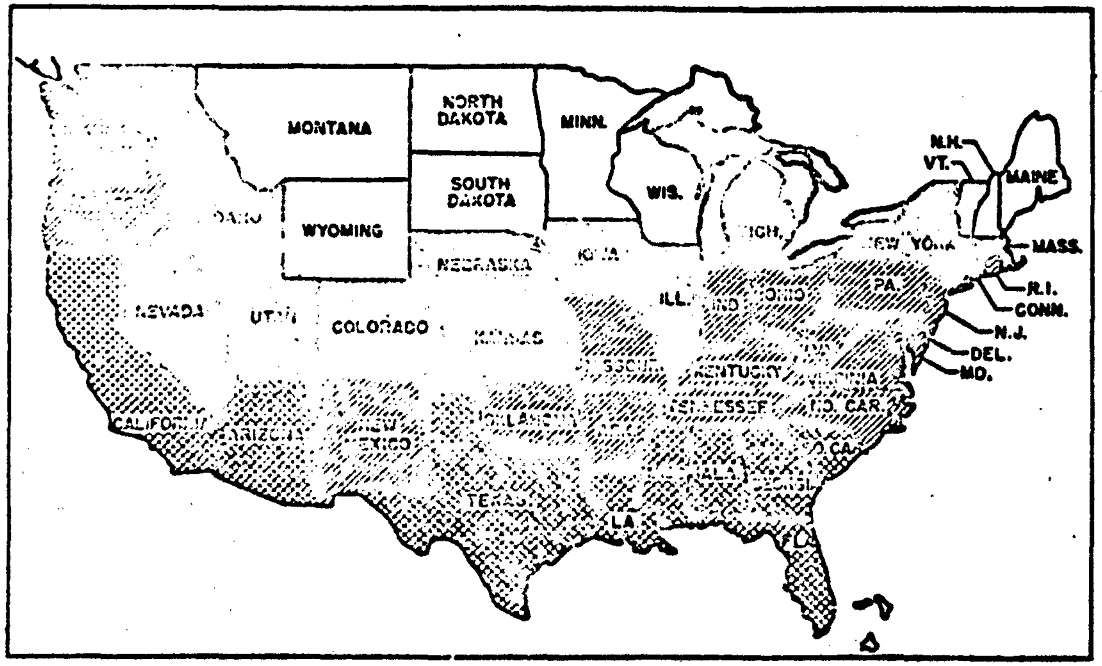
The 1951-52 data included information on state of origin of the cases as well as of bunker-mate and pre-exposure controls. In the interview the state in which the infantryman spent the greater portion of his life was recorded. In the pre-exposure study the states in which the front-line riflemen spent the second and third longest periods of their lives were also recorded. This latter data were

used as an index of migration between regions and revealed that approximately 80% (of 1,628 pre-exposure controls) either never left their region of birth or, if they moved from the region of their birth, they did not leave the general climatic zone (i.e. northerly or southerly). This, coupled with the fact that where migration did occur the state of longest residence was utilized in the subsequent calculations, minimized the factor of migration as it might affect either acclimatization or accustomization.

The same groupings of states were utilized as in Orr and Fainer's study. The source of the January minimum temperature averages was the United States Department of Commerce Weather Bureau (17) and involved temperatures recorded for periods of as long as 79 years.

The temperature for the state was derived by calculating the simple average of the readings at all the weather stations in that state. Since such stations, with the exception of one or two states, are more frequently located in larger centers of population within the state and since Selective Service procedures draw more men from more highly populated areas, the simple average rather than a weighted mean was considered adequate for the purpose.

The states were then grouped arbitrarily into four basic regions as indicated in Figure 12. A fifth region was included to account for Hawaii and Puerto Rico as extra-continental areas of the United States although their minimum January temperatures fell, by definition, into Region IV (temperatures of over 35° F.). Although calculations were performed for each region, comparisons for the analysis of individual factors were made between northern or colder zones (Regions I and II) and southern or warmer zones (Regions III,



"REGION" I 10.0°F. OR LESS | "REGION" II 10.1°F. TO 20.0°F. | "REGION" III 20.1°F. TO 35.0°F. | "REGION" IV 35.1°F. OR HIGHER

"REGION V" (NOT SHOWN) INCLUDES HAWAII AND PUERTO RICO

FIG. 12. MEAN DAILY MINIMUM JANUARY TEMPERATURES (°F) FOR THE INDIVIDUAL STATES.

IV and V). It must here be emphasized that reference to North and South is purely on a climatic basis and not on political or socioeconomic bases.

Table 115 reveals the fact that, although more front-line troops came from southerly regions (as judged by the pre-exposure sample) and more bunker-mate controls similarly came from these regions, the excess of cases of frostbite over the expected from the South was highly significant when compared to either control. Utilizing the pre-exposure sample as indicative of the states of origin of troops in Korea in 1950-51, the same significant excess of frostbite cases from the South was found.

Since distinct differences in the race-specific attack rates were found, the influence of climatic region or origin upon attack rates among Negroes and Whites had to be examined. Negro cases were separated from White cases and each compared by chi square contingency tables with the respective racial bunker-mate and pre-exposure controls. Both tests for the Negroes failed to show any regional differences (Appendix Tables 38 and 39). However, comparisons for the Whites revealed highly significant excesses of Southern cases over the expected according to the control distributions (Appendix Tables 40 and 41). With these differences in mind, relative attack rates were calculated for White and Negro according to climatic region and compared to the Northern Whites. Table 116 presents the data according to race and region of origin and utilizes the pre-exposure sample for regional distribution of the Eighth Army. It can be seen that, having equalized the case rate according to the percentages of race and region of origin,

TABLE 115

COMPARISON OF 701 CASES OF FROSTBITE, 452 EPIDEMIOLOGIC CONTROLS AND 1359 PRE-EXPOSURE CONTROLS WITH RESPECT TO CLIMATOLOGIC REGION OF ORIGIN
KOREA, 1951-52

Region	Cases		Epidemiologic Controls		Pre-Exposure Controls	
	No.	%	No.	%	No.	%
I	22	3.1	39	8.6	121	8.9
II	115	16.4	117	25.9	329	24.2
III	281	40.1	148	32.7	604	44.4
IV	228	32.5	100	22.1	275	20.2
V	55	7.8	48	10.6	30	2.2
Total	701	99.9	452	99.9	1359	99.9
Chi square	-		44.653		101.464	
P	-		<.001		<.001	
North (I,II)	137	19.5	156	34.5	450	33.1
South (III,IV,V)	564 (523)* (501)**	80.5	296	65.5	909	66.9
Chi square	-		32.490		41.789	
P	-		<.001		<.001	

* Expected on basis of Epidemiologic Controls
** Expected on basis of Pre-Exposure Controls

RESTRICTED
Security Information

TABLE 116

COMPARISONS OF RELATIVE RISKS OF ATTACK BY FROSTBITE BETWEEN WHITE AND NEGRO POPULATIONS OF THE UNITED STATES EIGHTH ARMY KOREA, 1951-52

Region and Race	% in Eighth Army (a) (Pre-Exposure Sample)	No. of Cases (b)	Adjusted Case Rate ($b \times \frac{1}{a}$)	"Risk of Attack" Ratios	
Northern White	32.6	113	346.57	1.000	1.000
Southern White	52.8	295	558.73	1.612	
Northern Negro	0.9	24	2666.66	7.694	5.058
Southern Negro	13.7	262	1912.34	5.518	
Total	100.0	694	-	-	-

ratios of risk of attack for both race and region were obtained. With the Northern White adjusted case rate as unity, the Southern White appeared to be 1.6 times, the Northern Negro 7.7 times and the Southern Negro 5.5 times at risk over the Northern White soldier. Chi square contingency calculations revealed that the difference in attack rate between the Northern and Southern White troops was highly significant, but the difference between Northern and Southern Negro soldiers was statistically not significant. In Table 117, there is summarized the relationships among the four categories of troops according to the chi square tests. It is obvious, with these two approaches reinforcing each other, that, whereas origin from Southern climatic regions increased the attack rates among White troops, no such relationship was found for the Negro. Furthermore the racial disparity in attack rate was once more emphasized for each of the climatic zones (North and South). Thus the race factor far overshadowed the factor of climatic region.

RESTRICTED
Security Information

TABLE 117

INTERGROUP COMPARISONS OF RISK OF ATTACK
KOREA, 1951-52

Group Comparison	Chi square	P
Southern Negro > Northern White	153.086	<.001
Southern Negro > Southern White	112.538	<.001
Northern Negro > Northern White	40.123	<.001
Northern Negro > Southern White	22.719	<.001
Southern White > Northern White	14.332	<.001
Northern Negro = Southern Negro	0.867	>.30

Irrespective of whether acclimatization or accustomization was responsible for the regional differences among the troops in Korea, an additional hypothesis relative to adjustment to the climatic environment was tested. It was argued that if acquired resistance to cold was related to exposure experience as in the animal (8), soldiers living in rural areas for the greater part of their lives should have had greater exposure and hence greater resistance as manifested by fewer cases of frostbite. This hypothesis could not be substantiated for both cases and controls revealed an almost identical distribution by rurality and urbanity (Table 118). Even separation into the racial and regional components failed to establish any significant relationships between type of residence and predilection to frostbite (Appendix Tables 42, 43 and 44). Though a tendency for city dwellers to have higher degrees of frostbite was noted among 577 cases of frostbite of the feet, this was not statistically significant (Appendix Tables 45 and 46). This evidence was inconclusive for no data were collected uniformly in regard to the type of occupation engaged in by these cases in civil-

TABLE 118

COMPARISON OF 702 CASES OF FROSTBITE AND 448 BUNKER-MATE CONTROLS WITH RESPECT TO TYPE OF RESIDENCE LIVED IN FOR GREATER PART OF LIFE KOREA, 1951-52

Type of Residence	Cases		Controls	
	No.	%	No.	%
Rural	158	22.5	106	23.7
Urban and suburban	544	77.5	342	76.3
Total	702	100.0	448	100.0
Chi square = 0.206 df = 1 P >.50				

ian life. Rural indoor and urban outdoor occupations could not be analyzed.

With the demonstration of greater frostbite attack rates for the Negro and for the Southern White, the data on severity of injury were reviewed on the basis of race and region to ascertain whether the Southern White soldiers showed higher degrees of injury than did the Northern Whites. No significant differences in severity of injury between Northern and Southern groups could be demonstrated (Tables 119 and 120). The significant differences noted were between the races per se. It must be emphasized that the classification of frostbite by depth of tissue damage without regard to extent of the damage may preclude such correlative studies.

Just as the several host and environmental factors were tested for differences between White and Negro cases in an attempt to determine the basis for the racial disparity, so were they analyzed to elicit the underlying reasons for the regional difference among

TABLE 119

RELATION OF DEGREE OF INJURY TO REGION OF ORIGIN AND RACE AMONG 336 WHITE AND 236 NEGRO CASES OF FROSTBITE OF THE FEET KOREA, 1951-52

Race	Degree of Injury - Feet										Chi square	P
	First		Second		Third		Fourth		Total			
	No.	%	No.	%	No.	%	No.	%	No.	%		
Northern White Northern Negro	41 6	43.2 35.3	32 6	33.7 35.3	18 4	18.9 23.5	4 1	4.2 5.9	95 17	100.0 100.0	0.467	>.90
Southern White Southern Negro	117 77	48.5 35.1	75 62	31.1 28.3	39 68	16.2 31.1	10 12	4.1 5.5	241 219	99 9 100.0	16.506	<.001
Northern White Southern White	41 117	43.2 48.5	32 75	33.7 31.1	18 39	18.9 16.2	4 10	4.2 4.1	95 241	100.0 99.9	0.894	>.80
Northern Negro Southern Negro	6 77	35.3 35.1	6 62	35.3 28.3	4 68	23.5 31.1	1 12	5.9 5.5	17 219	100.0 100.0	0.573	>.90
Total White Total Negro	158 83	47.0 35.2	107 68	31.8 28.8	57 72	17.0 30.5	14 13	4.2 5.5	336 236	100.0 100.0	16.828	<.001

RESTRICTED
Security Information

TABLE 120

RELATION OF DEGREE OF INJURY TO REGION OF ORIGIN AND RACE AMONG 104 WHITE AND 74 NEGRO CASES OF FROSTBITE OF THE HANDS
KOREA, 1951-52

Race	Degree of Injury - Hands										Chi square	P
	First		Second		Third		Fourth		Total			
	No.	%	No.	%	No.	%	No.	%	No.	%		
Northern White	13	59.1	5	22.7	2	9.1	2	9.1	22	100.0	4.749	>.10
Northern Negro	3	37.5	5	62.5	-	-	-	-	8	100.0		
Southern White	44	53.7	31	37.8	2	2.4	5	6.1	82	100.0	9.937	<.02
Southern Negro	23	34.8	31	47.0	9	13.6	3	4.5	66	99.9		
Northern White	13	59.1	5	22.7	2	9.1	2	9.1	22	100.0	1.825	>.50
Southern White	44	53.7	31	37.8	2	2.4	5	6.1	82	100.0		
Northern Negro	3	37.5	5	62.5	-	-	-	-	8	100.0	3.466	>.30
Southern Negro	23	34.8	31	47.0	9	13.6	3	4.5	66	99.9		
Total White	57	54.8	36	34.6	4	3.8	7	6.7	104	99.9	10.353	<.02
Total Negro	26	35.1	36	48.6	9	12.2	3	4.1	74	100.0		

RESTRICTED
Security Information

the White cases. Table 121 summarizes the individual factor findings according to Northern (Regions I and II) and Southern (Regions III, IV and V) climatic zones for Whites and Negroes.* The method of analysis was identical to that employed in the racial comparisons and its description will not be repeated here. Emphasis will be given the comparisons between Northern and Southern White cases of frostbite and the Negro cases will be referred to only when pertinent or contributory to the argument.

1. Mean Age

No differences were found between the climatic zones. This merely reiterates the general lack of association between frostbite and age in this physiologic age group.

2. Rank

For this factor which was fairly significant in the racial comparison, no significance could be demonstrated between Northern and Southern regions, although a slight trend toward higher ranks was noted among the Southern group. This would not support an hypothesis that the Northern regional attack rate was lower because of greater experience in combat and more frequently occurring elements of leadership.

3. Days in Korea

Greater familiarity with the Korean terrain and climate cannot be claimed for the Northern cases than for the Southern to account for their rate disparities. This was based on the lack of significant difference in the number of days the group spent in Korea.

* Basic data and calculations will be found in Appendix Tables 51 to 136 inclusive.

TABLE 121

SUMMARY OF ANALYSES OF FACTORS TESTED FOR REGIONAL DIFFERENCES IN WHITE AND NEGRO FROSTBITE KOREA, 1951-52

Item	Race and Region				Test of Significance	df	P
	White		Negro				
	N	S	N	S			
Mean age (yrs.)	22.0	22.0	22.3	21.5	t = 0.266 1.221	403 284	>.70 >.20
Rank	-	+	-	+	*χ^2 = 3.748 2.808	4 3	>.30 >.30
Days in Korea	-	+	-	+	χ^2 = 6.749 7.197	8 8	>.50 >.50
Days in combat	39.8	47.5	43.0	63.3	t = 1.733 2.282	393 271	>.05 <.05
Days in combat without rest	14.3	15.1	12.5	16.5	t = 1.187 1.214	390 260	>.20 >.20
Previous cold injury	+	-	-	+	χ^2 = 4.139 0.093	1 1	<.05 >.70
Previous illness (malaria)	-	+	-	-	χ^2 = 16.043 1.255	4 6	<.01 >.95
Smoking (packs)	1.0	0.8	1.0	0.7	t = 2.941 2.982	400 280	<.01 <.01
Hours since last meal before frostbite	7.2	8.7	6.1	9.6	t = 2.729 3.859	390 271	<.01 <.001
Content of last meal (hot meal)	+	-	-	+	χ^2 = 5.514 1.152	4 4	>.20 >.80
Footgear worn (adequate)	-	+	-	+	χ^2 = 4.673 6.443	6 6	>.50 >.30
Extra footwear carried	-	-	+	-	χ^2 = 2.302 0.655	4 4	>.50 >.95
Average change of socks (days)	1.4	1.5	1.7	1.7	t = 0.636 0.195	392 271	>.50 >.80
Average change of insoles (days)	1.5	1.3	1.4	1.5	t = 1.523 0.355	206 119	>.10 >.70
Sockgear worn	-	-	-	+	χ^2 = 2.839 6.126	6 6	>.80 >.30
Last change of socks (days)	1.0	1.1	1.1	1.2	t = 1.023 0.470	395 281	>.30 >.60
Condition of feet (dry)	+	-	+	-	χ^2 = 2.000 2.001	4 4	>.70 >.70
Condition of hands (dry)	-	+	+	-	χ^2 = 2.826 2.123	3 3	>.30 >.50
Activity	-	+	-	+	χ^2 = 13.310 10.824	8 8	>.10 >.20
Average min. temp. of exposure	10.9	12.0	16.5	13.6	t = 0.953 1.[illegible]	364 254	>.30 >.20

* χ^2 = Chi square

TABLE 121 (cont.)

Item	Race and Region				Test of Significance	df	P
	White		Negro				
	N	S	N	S			
Duration of exposure (hrs.)	11.2	10.6	x	x	t = 0.374	674	>.70
School grade completed	11.8	10.2	10.9	10.3	t = 2.589 1.077	49 65	<.01 >.20
AGCT score Area I	103.5	89.3	x	73.9	t = 1.570	24	>.10
AGCT score Area III	104.7	88.5	58.5	73.8	t = 1.763 1.408	24 43	>.05 >.10
Personal hygiene	+	-	+	-	χ^2 = 1.522 0.901	2 2	>.30 >.50

4. Days in Combat

If greater "battle-wisdom" played a chance role in one group or the other, this was certainly not borne out by the mean days in combat for Northern and Southern groups. A trend toward a higher mean was noted for the Southern cases.

5. Days in Combat Without Rest

If battle fatigue were greater for one group than the other, to account for greater frostbite incidence, a clue to this factor might be found in disparities in the mean time spent in combat without rest. According to the analysis of this factor in Table 121 and to the extent that days in combat without rest measures fatigue, no significant difference was found between the two groups.

6. Previous Cold Injury

Of interest in this analysis was the fact that a significantly greater number of Northern White cases gave a history of previous cold injury. Since previous cold injury was found in an

earlier discussion to bear a distinctly positive relationship to the incidence of frostbite, this fact should have operated against there being an excess of frostbite cases due to this factor in the South; or, conversely, should have increased the probability of subsequent frostbite among Northern White troops. Since an excess occurred in the South other factors must have operated in producing an over-all higher incidence of frostbite among the White troops from the Southern climatic regions despite the more frequent history of previous cold injury in the North. This relationship is quantitatively set forth in Table 122. Utilizing the distribution of previous cold injury among the pre-exposure controls as an indicator for the expected number of cases with previous cold injury, the actual number of cases of frostbite who gave histories of cold injury was compared by the chi square technique. These comparisons were made for race and region. It can be seen that both Northern (chi square = 5.002) and Southern (chi square = 30.174) White cases had significant excesses of cases with history of previous cold injury over the number expected. Similarly, the Southern Negro cases showed a significant excess (chi square = 7.126). (The chi square value for the Northern Negro was unreliable because of the small size of the expected value.) These individual component chi square values as well as that for the experience as a whole (chi square = 43.635) merely reiterated the finding of a significant excess of frostbite cases with a history of previous cold injury. Tests for interaction of this

TABLE 122

EXPECTED AND ACTUAL INCIDENCE OF FROSTBITE CASES WITH HISTORY OF PREVIOUS COLD INJURY BY RACE AND REGION
KOREA, 1951-52

Region & Race	Pre-Exposure Sample			No. of Cases Frost-bite	Expected No. Cases with Previous Cold Injury	Actual No. Cases with Previous Cold Injury	Difference	Chi square	Σ Chi square
	Previous Cold Injury	Total	% Previous Cold Injury						
Northern White Southern White	93 71	487 786	19.1 9.0	109 274	20.8 24.7	31 52	10.2 27.3	5.002 30.174	
White Subtotal	164	1273	12.9	383	49.4	83	33.6	22.853	35.176
Northern Negro Southern Negro	6 28	25 249	24.0 11.2	21 249	5.0 27.9	3 42	2.0 14.1	1.333 7.126	
Negro Subtotal	34	274	12.4	270	33.5	45	11.5	3.948	8.459
Grand Total	198	1547	12.8	653	83.6	128	44.4	23.580	43.635

factor with region and race revealed that previous cold injury did not affect the groups equally.* Secondly, tests of interaction between previous cold injury and region revealed that region contributed significantly to this excess.** Finally, tests of interaction between previous cold injury and race revealed that race did not contribute to the excess.*** Therefore by this technique the more prominent role of climatic region was noted in the interaction with previous cold injury. Thus it was concluded that, by subtracting the contrary effect of a greater incidence of previous cold injury among Northern cases, the effect of climatic region of origin on production of frostbite was amplified.

7. Previous Illness

As might be expected from knowledge of the extent of the endemic reservoir of malaria the Southern cases gave a history of this disease significantly more often. That this factor was purely coincidental and indigenous to Southern regions rather than contributory in any way to the excess of frostbite cases from Southern regions was shown by the synonymous distribution of this item among the White control subjects.

8. Smoking

Just as in the racial comparison, so in the regional comparison was a significant difference in the amount of smoking

---

*Σ(chi square)-chi square = 43.635-23.580 = 20.055; df = 3 P <.001
**Σ(chi square)-chi square = 35.276-22.953 = 12.323; df = 1 P <.001 and also
Σ(chi square)-chi square = 8.459- 3.948 = 4.511; df = 1 P <.05
***Σ(chi square)-chi square = 38.215-(30.174 + 7.126) = 0.915; df = 1 P >.30
(Southern White plus Southern Negro only since the number of Northern Negro cases were too few for reliability)

found. In the latter instance the Southern cases smoked less than the Northern. It should be recalled, first, that the cases as a whole smoked significantly less tobacco than did the controls. Secondly, the Negro cases smoked significantly less than the White cases. The finding of less smoking among another group with significantly higher attack rate for frostbite, namely the Southern White cases, therefore emphasized this factor (or lack of it) as associated with frostbite. The controls did not show this regional difference. The concept of an underlying personality complex or at least some psychophysiologic factor must be considered seriously. No claims can be made that less smoking among Southern White cases resolves the problem of the difference in attack rates any more than that less smoking among Negro cases resolves the question of racial disparity. This feature may be a reflection of behavior common to Negroes and Southern Whites (in that order) which in turn may be conducive to a poorer adjustment to the needs of cold weather survival.

9. Interval Since Last Meal Before Frostbite

Unlike the situation among the controls the Southern White frostbite cases showed a significantly longer interval between the last meal and the onset of their frostbite than the Northern White cases. This factor took on even greater significance when a tendency for the Northern White cases to have had a hot meal in more instances was noted, though the reason for this difference in the interval since the last meal was not at all clear.

10. Bootgear Worn

No significant difference was noted between the Northern and Southern White cases in regard to the adequacy of bootgear for the temperature and ground condition.

11. Extra Footwear Carried

The Northern and Southern White cases revealed no differences in regard to the quantity and type of extra footwear which they carried for changing.

12. Average Change of Socks

No significant difference in average interval between sock changes was noted between the two climatic zones.

13. Average Change of Insoles

The average interval between changes of insoles in shoepacs was also not significantly different between Northern and Southern cases.

14. Sockgear Worn and Last Change of Socks

Both Northern and Southern White cases wore the same type and quantity of sockgear at the time of their cold injuries and had last changed their socks at virtually identical intervals.

15. Condition of Feet

Although the Northern White cases tended to have had more instances of dry feet at time of injury, no significant difference from the Southern White cases was noted.

16. Condition of Hands

Among the hand cases of frostbite the Northern and Southern Whites did not reveal any significant differences in the con-

dition of the hands at the time of injury.

17. Activity at Time of Injury

Although it was shown earlier that the frostbite cases were significantly less active than the controls in identical environmental situations, this factor was apparently noncontributory to the regional difference in attack rates. There was a tendency for the Southern White cases to have been somewhat more active than the Northern White frostbite cases.

18. Average Minimum Temperature of Exposure

Both Northern and Southern White cases were apparently exposed to virtually the same minimum temperatures as evidenced by a lack of statistical significance in the difference between the average minimum temperatures of exposure for the two groups.

19. Duration of Exposure

Both groups were exposed to the low ambient temperatures for virtually identical lengths of time.

20. School Grade Completed

Although no significant racial difference was found for the highest school grade completed by the cases of frostbite, a statistically significant difference of 1.6 years to the advantage of the Northern White cases was observed. If the quality of education was considered, the difference in educational achievement may have been even greater than that represented by 1.6 years. The difference between the Northern and Southern White cases relative to this factor became even more provocative when it was noted that the average school

school grade completed by Southern Whites virtually equaled that achieved by the Southern Negro cases and, for that matter, all Negro cases irrespective of region. Certainly greater education should augment attributes pertinent to accustomization and the significance of this factor will be discussed below.

21. AGCT Scores

There was a distinct tendency for the Northern White cases to have higher AGCT scores in Aptitude Areas I and III. These scores may well reflect, in part at least, the educational achievement of the four race-region groups as noted above.

22. Personal Hygiene

No regional differences in personal hygiene were noted but the degree of reliability of this data must be kept in mind as discussed in the section on racial attack rates.

M. Acclimatization vs. Accustomization

The evidence for acclimatization of man to cold is at best tenuous and not as firmly grounded as acclimatization to heat. Although acclimatization to heat in man is lost rather quickly one may only speculate that such is also the case in acclimatization to cold for only animal studies exist in this regard (8). If this is also true for man and loss of acclimatization on a physiologic basis occurs in about a month, then the effects of climatic origin on such acclimatization would certainly not have carried through a Korean summer. This conjecture denies, of course, the possible residual effects of repeated winter acclimatizations among those troops who have lived most of their lives in northern regions and

the possibility of long term acclimatizations as yet not demonstrated. These possibilities, though not very likely, have not been disproven. In the present study no direct concrete evidence for acclimatization of a physiologic character has been educed. The analysis of the several factors studied was designed to weigh other possibilities as contributory to the difference in attack rates between the climatic zones. Among these possibilities is the concept of accustomization to cold (psychological acclimatization, adaptation or experience).

The case for accustomization can be oversimplified because it is somewhat easier to speak of gaining experience and "know-how" from having lived in the colder environment than to exact rigid, demonstrable physiologic changes. The case for accustomization should be equally, if not more, exacting especially where psychological and educational factors are implicated. The ACCT scores in Aptitude Areas I and III and the grade completed in school would tend to support the concept of accustomization, for the Northern Whites could be said to have had the more nearly adequate education and the greater aptitude for adapting to cold weather. These factors would certainly strengthen the behavioral patterns for living <u>with</u> the cold established by having lived <u>in</u> the cold for the greater part of their lives. The Negro, on the other hand, could be thought of as having been sufficiently lower on the scale of education and aptitude so that regional differences for him were obliterated. The proof of this concept is, however, not this simple, for significant differences would be expected among those factors stemming directly from education, orientation, training,

greater aptitude and its corollary better receptivity. There would be expected differences in the adequacy of bootgear-sock-gear combinations worn and the frequency of change of socks and insoles. The soldier acc stomed to living with cold would be expected to have been more actively engaged in moving his legs and arms whenever the situation permitted, could be expected to have carried extra footwear for changing at every opportunity and would more frequently have had dry feet and hands. No differences between regions were elicited for any of these factors (Table 12). This relative lack of confirmatory evidence for the accustomization hypothesis does not negate it, however, for other less measurable factors in the psychosocial category might, if data were available, support the hypothesis. These factors are the ones alluded to in the discussion on differences in racial attack rates and include, among others, factors of morale and self-discipline as well as the early home environment and behavioral patterns. As an example, it is conceivable and even highly probable that a soldier raised in a warm climate could for psychological reasons be at a lower level of morale when thrust into combat in a cold environment.

To this point, though acclimatization cannot be rejected as a basic or contributory cause for the regional differences in frostbite rates among White soldiers, the hypothesis of accustomization appears to be a more likely one. Nevertheless the differences in regional attack rates were highly significant. Irrespective of the underlying cause or causes which this study failed to demonstrate conclusively, the Southern White soldier was at greater risk of

attack by frostbite than the Northern White. The practical military implication of this finding was identical to that described for the racial difference. Emphasis on training and orientation is reiterated and the recognition by unit commanders of these "special risk" groups should be part of the command responsibility.

X. SUMMARY AND CONCLUSIONS

An epidemiologic study of the relationship of cold trauma to the combat soldier in Korea in 1951-52 has been presented. Data on 716 cases and 466 bunker-mate controls were analyzed. In addition, selected data on 1,428 pre-exposure controls were utilized. This study yielded the following findings:

1) The front-line rifleman was once more shown to be at greatest risk of attack by cold even in a static defense situation. The army attack rate was 3.04 per 1,000, the divisional attack rate was 6.0 per 1,000, regimental rate was 8.6 per 1,000 and battalion rate, 11.2 per 1,000 or a ratio of approximately 1:2:3:4.

2) Most frostbite occurred in the early morning hours during patrols and guard duty in front-line bunkers or foxholes and under enemy attack.

3) Relatively high linear correlations of frostbite incidence with daily average temperature, daily minimum temperature and daily average windchill were obtained. Separation of data according to intensity of combat permitted reasonably reliable prediction formulae to be calculated. Though applicable only to comparable situations, the method appears to hold promise for future prediction calculations in other types of situations. The mean daily minimum temperature to which the cases were exposed was 11° F. and the absolute lowest temperature was -11° F. The mean windchill during exposure of the cases were 840 Kg. cal/M²/hr. and the highest daily mean windchill was [illegible] Kg. cal/

M^2/hr.

4) Though no relationship between temperature and severity of injury could be established, hand cases seemed to require, on the average, 5 degrees (F.) lower temperature exposure than did foot cases.

5) The mean duration of exposure was 10 hours, but varied with the specific type of activity.

6) An attempt was made to establish a gradient of injury according to an exposure-index principle utilizing the product of temperature and duration of exposure. Trends were noted for a direct relationship between degree of injury and exposure-index. Its shortcomings were discussed, but the technique was recommended for future studies with more nearly adequate classification of severity of injury.

7) Although condition of the ground did not play a major role in the incidence of frostbite it did affect the severity of injury of the feet. Wet ground was significantly associated with higher degrees of injury. Ground condition did not affect the severity of hand cases.

8) The relationship between combat activity and frostbite incidence was masked by other environmental factors on a regimental basis, but became apparent when case-exposure rates were calculated:

   a) Troops in reserve had 2.3 cases per 100,000 man-days of exposure.

b) Line troops in static defense showed 4.9 cases per 100,000 man-days of exposure.

c) Line troops in active defense experienced 43.2 cases per 100,000 man-days of exposure. (This included the partial effect of inadequate bootgear.)

9) Although both cases and bunker-mate controls were exposed to similar environmental factors including specific micro-activity such as immobilizing enemy action, the cases showed markedly less muscular movement than did the controls.

10) Most cases of frostbite occurred while troops were engaged in an activity on top of the ground such as patrolling or standing guard.

11) In a sample of 275 frostbite cases distributed similarly to the total case load in regard to division, date of injury and race, body clothing was found relatively adequate. Injured part specific comparisons revealed relative inadequacies in handgear among hand cases, bootgear among foot cases and headgear among ear cases.

12) Although the absolute number of frostbite cases of the feet occurring in shoepacs was greater, calculations equalizing exposure revealed the leather combat boot to be more conducive to injury and more frequently leading to greater severity of injury.

13) The following bootgear-sockgear combinations were apparently inadequate in insulating power for the climatic conditions

and led to a significantly greater number of frostbite cases:

a) A single pair of cushion sole socks in leather boots.

b) A single pair of cushion sole socks in shoepacs.

14) Bootgear-sockgear combinations found to be constrictive and presumably conducive to frostbite were:

a) Two pair cushion sole socks in leather boots.

b) One pair ski socks in leather boots.

15) Combat troops frequently failed to carry extra footwear (socks and insoles) for changing whenever the situation permitted. Of 252 cases in situations permitting sock and insole change, only 77% carried this extra footwear; whereas of 214 controls in similar situations, 92% carried extra footwear.

16) Hand cases revealed a significant excess wearing either no handgear or incomplete ensembles at the time of injury.

17) Although the insulated rubber combat boot did not completely prevent frostbite of the feet, it did cause a significant reduction in the incidence of cold injury during the winter of 1951-52.

18) The cases wearing leather combat boots showed a relatively higher incidence of wet feet from external water than did controls. The shoepacs similarly permitted entry of external water through the top and through tears with resulting loss of insulation. Severity of injury was greater in cases wet with external liquids.

19) Inadequate insole change contributed significantly to frostbite incidence in troops wearing shoepacs. Change of socks, though significantly inadequate, was not a major factor contributing to incidence.

20) Rank was an obvious factor in frostbite incidence and reflected the occupational selectivity of cold injury for the front-line rifleman. The calculated rate among sergeants at identical risk was 4.2 per 1,000 as compared to 13.0 per 1,000 for privates and corporals. Evidence was presented to indicate that elements of leadership may have operated in the more favorable attack rate among sergeants as compared to the lower risks.

21) Previous cold injury was incontrovertibly shown to predispose to frostbite. The attack rate among soldiers not previously cold injured was 2.6 per 1,000 compared to 5.0 per 1,000 for soldiers previously cold injured.

22) Evidence was presented that fatigue played a contributory role to the incidence of frostbite.

23) The use of tobacco showed no relationship to frostbite. Actually the cases smoked significantly lesser amounts than their bunker-mate controls.

24) Some evidence was presented that the frostbite case tended to be a bradycardic individual. His mean pulse rate was 75.3 per minute compared to 86.8 per minute for the controls.

25) The frostbite cases tended to have significantly lower AGCT scores (mean score Area I = 80.9) than did the con-

trols (mean score Area I = 90.7) indicating the possible role of education, aptitude and skill in minimizing the risk from frostbite although the needs beyond primitive intelligence were not clear.

26) Collateral evidence was demonstrated to strengthen the impressions from the neuropsychiatric study that the frostbite case tended to be a passive, negativistic, hypochondriacal individual. This evidence included the factors of less muscular activity in situations permitting greater activity as demonstrated by the controls, relative inattention to carrying extra footwear and less smoking.

27) The Negro was proven to be significantly at greater risk of attack by frostbite (six times) with all environmental conditions equalized. At the regimental level his rate was 35.9 per 1,000 compared to 5.8 per 1,000 for the White soldier. Negroes showed more severe injuries than Whites. Differences in tissue susceptibility were neither proven nor disproven, but evidence was found to indicate that lower aptitude and knowledge may have played a role in the greater Negro attack rate.

28) The climatic region of origin of the soldier was shown to be a highly significant factor among White troops in the incidence of frostbite. Origin from the warmer climates of the United States (or Hawaii and Puerto Rico) predisposed to frostbite. The role of acclimatization and accustomization was discussed and more evidence for accustomization seemed to be present.

29) The racial factor so outweighed the climatic region factor as to obscure the latter among Negroes.

XI. RECOMMENDATIONS FOR PREVENTION

The following recommendations are presented as high lights or new items of prevention rather than a comprehensive listing of all measures previously known or recommended:

1) Weather consciousness is a sine qua non in the prevention of cold injuries. Each unit should take an active part in local weather observations and predictions so that its practical application to the proper wearing of clothing and length of exposure within the limits of military expediency may be realized.

2) Immobilization is a major factor contributing to cold injury. Troops should be impressed with the need for muscular movement to the fullest extent which the combat situation permits.

3) The wearing of items of body clothing should be predicated upon the existing or predicted weather conditions rather than on the basis of army-wide directives relating to seasons.

4) Front-line units should be equipped with properly fitted new insulated rubber boots for winter combat whenever possible. Cognizance should, however, be taken of the several shortcomings of the boot described in other sections of this report and even greater attention paid to foot hygiene while wearing the boot.

5) Greater attention should be paid to proper footgear-sockgear

combinations to avoid either inadequate insulation or constriction.

6) Extra footwear should be carried at all times so that the soldier may take advantage of any opportunity for change and not be guided blindly by "daily change" directives.

7) Daily inspection of the feet by the squad leader to include boot and sockgear adequacy should be mandatory and unit commanders should require verbal reports of such inspections.

8) Handwear should be fastened by neck cords to prevent loss and extra shells provided in addition to the usual extra inserts.

9) Cold weather orientation and training should be extended into the combat theater and simple educational techniques of a public health nature employed to keep both the problem and its prevention before the troops at all times. Repetition is essential.

10) The "special risk" groups (Negroes and White troops from Southern climatic regions) should be given greater attention in orientation, winter combat training, teaching of foot hygiene and in inspection. Unit commanders should recognize that, to retain these groups as effective rifle power in the line, personal attention to preventive measures among them will be necessary.

11) Since previously cold injured soldiers are at twice the risk of attack by cold, such cases should not be returned to situations in which exposure risk is great.

12) Cold Injury Control Officers with full freedom of investigation and report should be stationed with each unit of company size or larger. These officers should, in addition to their indoctrinational duties in training and orientation, advise on correction of irregularities of supply and utilization of gear in tactical operations.

13) As combat conditions permit, warm-up facilities should be extensively used.

14) Every opportunity for rest back of the lines should be provided as battle activity permits. Evidence exists that some soldiers did not avail themselves of trips to showers which afforded an opportunity for brief rest.

XII. RECOMMENDATIONS FOR FURTHER STUDY

1. Further epidemiologic field studies of cold injury should be undertaken to provide additional quantitative data, especially on unresolved problems.

2. Multiple factor analysis should be applied to such data to derive relative weights of importance of the several factors involved in cold injury.

3. Correlation measurements for temperature and incidence data should be extended to the several types of combat situations.

4. The relationship between temperature and duration of exposure and degree of injury should be reassessed when more nearly adequate classifications of severity have been formulated.

5. Refinement of clothing and footwear data on the basis of clo values of insulation would be desirable for incidence rates.

6. Front-line surveys of personal and especially foot hygiene should be made and based on specific items of observation rather than

total impressions.

7. Psychological tests of morale should be devised and applied to survey groups to determine the relationship of this attribute to cold injury incidence.

8. To assess the role of cold weather orientation and training, this type of instruction should be entered on the soldier's service record by date and quantity of hours.

9. Pre-exposure studies, if repeated, should be on a much larger scale and should include, for example, reliable tests of vasomotor stability.

10. The neuropsychiatric aspects of the cold injury problems are provocative and should be explored further. Psychological testing and psychiatric examination of an adequate sample of cases and controls should be executed with the concept of a "cold-susceptible personality-complex" in mind.

11. The inquiry into the underlying factors in the racial and climatic region of origin differences in attack rates should be extended to the psychosocial factors so that finite preventive or selective actions may be taken.

12. If conditions permit, these studies should be extended to other United Nations units to elicit differences from United States troops. Such a study is always fraught with difficulties of language and culture but may provide the reference points of departure in such factors as training, hygiene, morale and accustomization.

XIII. BIBLIOGRAPHY

1. Goldberger, J. Nature and prevention of pellagra. Pub. Health Rep. 42: 2193, 1927.

RESTRICTED
Security Information

2. Paul, J. R. Epidemiology of rheumatic fever. Am. J. Med. 2: 66, 1947.

3. Levin, M. L. Epidemiologic features of cancer. Cancer 1: 489, 1948.

4. Gordon, J. K. Epidemiology of accidents. Am. J. Pub. Health. 39: 504, 1949.

5. Panum, P. L. Observations made during the epidemic of measles on the Faroe Islands in the year 1846. Translated from the Danish by Joseph Dimont. New York Delta Omega Society, 1940.

6. Whayne, T. F. Cold injury in World War II. A study in the epidemiology of trauma. Thesis, Harvard School of Public Health, 1950.

7. Orr, K. D. and D. Fainer. Cold injuries in Korea during winter of 1950-51. Medicine 31: 177, 1952.

8. Blair, J. R. and J. M. Dimitroff. Effect of cold-acclimatization upon resistance to cold injury in rabbits and rats. AMRL Project No. 6-64-12-028, Report No. 91, 1952.

9. Burton, A. C. In transactions of the second cold injury conference, Nov. 20-21, 1952. New York, Josiah Macy, Jr. Foundation, In Press.

10. Berson, P. C. and B. J. Angelucci. Trenchfoot. Bull. U. S. Army M. Dept. 77: 91, 1944.

11. Toone, E. C. and J. P. Williams. Trenchfoot: Prognosis and Disposition. Bull. U. S. Army M. Dept. 2: 198, 1946.

12. Gahrbandt, E. The return to service of soldiers who have suffered from frostbite. Abstr. Bull. War Med. 5: 552, 1945.

13. Stray, Kristian. Experimental investigations of the reaction of the skin to cold. Skrifter utgitt av det Norske Videnskaps-Akademi i Oslo I. Mat. Naturv. Klasse. 3: 66, 1943.

14. Blair, J. R., F. W. Urbush and I. T. Reed. Preliminary observations on physiological, nutritional and psychological problems in extreme cold. MDFRL Project No. 57-3, 3 July 1947.

15. Adolph, E. F. Oxygen consumptions of hypothermic rats and acclimatization to cold. Am. J. Physiol. 161: 359, 1950.

RESTRICTED
Security Information

16. Kark, R. In transactions of the first cold injury conference, June 4-5, 1951. New York, Josiah Macy, Jr. Foundation, 1952.

17. U. S. Dept. of Commerce, Weather Bureau, Technical Paper No. 9. Temperatures at selected stations in the United States, Alaska, Hawaii and Puerto Rico. Washington, D. C., Government Printing Office, December 1948.

APPENDIX I

MISCELLANEOUS EPIDEMIOLOGIC TABLES

(Tables 6a, 6b, 6c, 6d, 7a, 7b, 47, 48, 49 and 50 are not referred to in the text)

APPENDIX TABLE 1

DAILY INCIDENCE OF FROSTBITE, AVERAGE TEMPERATURES, MINIMUM TEMPERATURES AND AVERAGE WINDCHILL
KOREA, 1951-52

Date	Number of cases (y)	Average Temperature (x_1)	Minimum Temperature (x_2)	Average Windchill (x_3)
21 Nov '51	2	46	23	478
22 Nov	9	42	27	545
23 Nov	37	31	17	659
24 Nov	44	28	15	724
25 Nov	49	23	10	661
26 Nov	52	17	-2	978
27 Nov	22	21	7	876
28 Nov	10	20	6	831
29 Nov	10	29	15	696
30 Nov	5	28	10	610
TOTAL	240			
MEAN	24.0	28.5°	12.8°	705.8

APPENDIX TABLE 1 (Cont.)

Date	Number of Cases (y)	Average Temperature (x_1)	Minimum Temperature (x_2)	Average Windchill (x_3)
1 Dec '51	6	30	12	580
2 Dec	5	32	16	616
3 Dec	1	34	19	567
4 Dec	2	34	19	627
5 Dec	1	30	16	636
6 Dec	2	31	14	603
7 Dec	1	32	20	571
8 Dec	1	30	18	682
9 Dec	2	30	16	591
10 Dec	4	36	20	560
11 Dec	3	33	20	630
12 Dec	0	32	15	646
13 Dec	0	33	16	719
14 Dec	2	25	6	826
15 Dec	5	22	5	917
16 Dec	3	22	4	758
17 Dec	0	26	4	638
18 Dec	0	33	12	604
19 Dec	0	32	14	554
20 Dec	1	36	17	601
21 Dec	0	36	19	550
22 Dec	0	42	17	502
23 Dec	1	31	15	651
24 Dec	0	29	10	691
25 Dec	2	28	13	650
26 Dec	3	27	11	722
27 Dec	6	20	-4	744
28 Dec	11	14	-9	813
29 Dec	5	9	-17	768
30 Dec	2	18	-11	686
31 Dec	2	28	6	635
TOTAL	71			
MEAN	2.3	28.9°	10.7°	656.7

APPENDIX TABLE 1 (Cont.)

Date	Number of Cases (y)	Average Temperature (x_1)	Minimum Temperature (x_2)	Average Windchill (x_3)
1 Jan '52	7	18	- 4	762
2 Jan	4	18	- 6	724
3 Jan	4	26	7	688
4 Jan	2	26	5	723
5 Jan	3	20	- 5	718
6 Jan	2	21	2	752
7 Jan	8	13	- 8	857
8 Jan	11	13	-10	839
9 Jan	7	16	-10	755
10 Jan	6	28	- 3	649
11 Jan	6	17	- 2	795
12 Jan	41	16	-10	805
13 Jan	2	20	- 9	695
14 Jan	1	28	10	645
15 Jan	3	24	10	795
16 Jan	5	28	3	748
17 Jan	6	20	1	801
18 Jan	3	12	- 5	888
19 Jan	0	26	12	717
20 Jan	2	29	12	653
21 Jan	1	31	8	700
22 Jan	7	23	- 1	747
23 Jan	7	24	- 2	693
24 Jan	9	24	- 2	743
25 Jan	16	9	- 8	942
26 Jan	21	13	- 8	775
27 Jan	6	28	3	625
28 Jan	2	34	3	606
29 Jan	5	28	2	674
30 Jan	3	19	1	883
31 Jan	6	16	- 6	779
TOTAL	206			
MEAN	6.6	21.6°	-0.7°	747.6

RESTRICTED
Security Information

APPENDIX TABLE 1 (Cont.)

Date	Number of Cases (y)	Average Temperature (x_1)	Minimum Temperature (x_2)	Average Windchill (x_3)
1 Feb '52	8	19	- 2	803
2 Feb	17	10	- 6	931
3 Feb	17	10	-11	885
4 Feb	22	9	-12	943
5 Feb	19	9	-18	889
6 Feb	26	14	-10	750
7 Feb	3	28	2	647
8 Feb	4	23	- 2	694
9 Feb	4	28	5	682
10 Feb	2	23	- 4	762
11 Feb	0	28	9	648
12 Feb	0	34	15	596
13 Feb	0	33	19	586
14 Feb	0	34	20	600
15 Feb	3	33	12	641
16 Feb	2	24	6	765
17 Feb	1	18	- 3	780
18 Feb	6	17	- 5	794
19 Feb	9	16	- 4	804
20 Feb	5	23	1	773
21 Feb	0	25	2	735
22 Feb	11	22	0	759
23 Feb	9	14	- 5	835
24 Feb	3	23	4	693
25 Feb	4	26	12	684
26 Feb	7	28	10	682
27 Feb	1	29	10	650
28 Feb	0	26	9	669
29 Feb	1	29	6	677
TOTAL	184			
MEAN	6.3	22.6°	2.1°	736.4

RESTRICTED
Security Information

RESTRICTED
Security Information

APPENDIX TABLE 1 (Cont.)

Date	Number of Cases (y)	Average Temperature (x_1)	Minimum Temperature (x_2)	Average Windchill (x_3)
1 Mar '52	0	32	17	644
2 Mar	0	31	11	728
3 Mar	2	25	10	852
4 Mar	0	22	5	763
5 Mar	1	24	2	729
6 Mar	0	31	8	624
7 Mar	1	36	17	589
8 Mar	0	33	21	626
9 Mar	0	36	19	579
10 Mar	1	32	16	695
11 Mar	0	29	7	713
12 Mar	0	32	12	752
13 Mar	0	40	10	450
14 Mar	0	39	23	579
15 Mar	0	41	22	552
16 Mar	0	43	23	516
17 Mar	0	43	22	516
18 Mar	0	41	24	554
19 Mar	1	36	14	622
TOTAL	6			
MEAN	0.3	34.0°	14.9°	635.9
GRAND MEAN	5.9	26.2°	6.5°	700.6
S.D.	± 9.66	± 8.29	± 10.23	± 106.42
GRAND TOTAL	707			
COEFF. CORR.		-.4209	-.3245	+.4306
Sy	-	8.76	9.15	8.72

RESTRICTED
Security Information

RESTRICTED
Security Information

APPENDIX TABLE 2a

WEEKLY COLD INJURY RATE (PER 1000 PER ANNUM) FOR DIVISIONS, REGIMENTS AND SUPPORT ELEMENTS, UNITED STATES EIGHTH ARMY KOREA, NOVEMBER 1951

Unit	3 Nov. 51	10 Nov. 51	17 Nov. 51	24 Nov. 51
1st Cav. Div.	2.8	0	0	8.5
5th Reg.				26.1
7th Reg.	13.5			13.5
8th Reg.				
Support				
1st Mar. Div.	0	0	0	1.7
2nd Inf. Div.	0	0	0	7.8
9th Reg.				15.0
23rd Reg.				
38th Reg.				14.1
Support				5.2
3rd Inf. Div.	0	0	0	51.3
7th Reg.				126.7
15th Reg.				149.3
65th Reg.				74.9
Support				4.5
7th Inf. Div.	0	0	0	152.6
17th Reg.				717.5
31st Reg.				
32nd Reg.				30.5
Support				
24th Inf. Div.	0	0	0	7.5
5th Reg.				15.8
19th Reg.				16.8
21st Reg.				15.4
Support				
25th Inf. Div.	0	2.2	0	0.7
14th Reg.				
27th Reg.		12.9		
35th Reg.				27.5
Support				6.1
Misc. Eighth Army Units	0	0	0	0
Total	0.2	0.2	0	18.4

RESTRICTED
Security Information

RESTRICTED
Security Information

APPENDIX TABLE 2b

WEEKLY COLD INJURY RATE (PER 1000 PER ANNUM) FOR DIVISIONS, REGIMENTS AND SUPPORT ELEMENTS, UNITED STATES EIGHTH ARMY KOREA, DECEMBER 1951

Unit	1 Dec. 51	8 Dec. 51	15 Dec. 51	22 Dec. 51	29 Dec. 51
1st Cav. Div.	13.5	0	0	-	-
5th Reg.	24.2				
7th Reg.					
8th Reg.	41.0				
Support					
1st Mar. Div.	3.6	0	0	0	1.8
2nd Inf. Div.	0	0	0	2.6	2.6
9th Reg.				13.9	
23rd Reg.					
38th Reg.					14.0
Support					
3rd Inf. Div.	126.3	10.1	12.6	2.5	2.5
7th Reg.	273.3		26.0		13.0
15th Reg.	53.9		13.5	13.5	
65th Reg.	349.7	42.0	14.0		
Support		5.8	5.8		
7th Inf. Div.	181.3	11.0	8.2	0	13.7
17th Reg.	631.8	57.4	14.3		57.4
31st Reg.	53.8				13.5
32nd Reg.	13.7		13.7		
Support	20.4				
24th Inf. Div.	35.7	7.7	10.2	0	25.5
5th Reg.	61.4	15.4	30.7		76.8
19th Reg.	15.7	15.7	15.7		15.7
21st Reg.	109.6	15.6			62.6
Support	10.0		5.0		
25th Inf. Div.	24.4	0	5.4	0	5.4
14th Reg.	14.2				
27th Reg.					
35th Reg.	51.9		13.0		13.0
Support	26.9		6.7		6.7
45th Inf. Div.	0	2.6	0	2.6	13.[illegible]
179th Reg.		13.0		13.0	26.1
180th Reg.					36.0
279th Reg.					
Support					
Misc. Eighth Army Units	2.9	0.4	0.7	0.4	1.1
Total	30.8	2.6	3.2	0.8	5.6

RESTRICTED
Security Information

APPENDIX TABLE 2c

WEEKLY COLD INJURY RATE (PER 1000 PER ANNUM) FOR DIVISIONS, REGIMENTS AND SUPPORT ELEMENTS, UNITED STATES EIGHTH ARMY KOREA, JANUARY 1952

Unit	5 Jan. 52	12 Jan. 52	19 Jan. 52	26 Jan. 52
1st Mar. Div.	2.1	2.1	6.4	2.1
2nd Inf. Div.	2.2	24.4	2.2	2.2
9th Reg.		13.7		
23rd Reg.				
38th Reg.		94.3		13.5
Support	4.3	12.9	4.3	
3rd Inf. Div.	5.2	26.1	0	2.6
7th Reg.	26.8	13.4		13.4
15th Reg.				
65th Reg.		98.3		
Support		12.1		
7th Inf. Div.	8.2	24.5	2.7	32.7
17th Reg.	13.7	27.4		13.7
31st Reg.		48.9		73.4
32nd Reg.	26.8	26.8		67.0
Support		7.2	7.2	
24th Inf. Div.	13.6	59.0	18.2	27.2
5th Reg.	15.4	61.4	15.4	76.8
19th Reg.		15.7	15.7	
21st Reg.	15.9	111.3	31.8	15.9
Support	10.8	10.8		
25th Inf. Div.	0	2.7	5.3	8.0
14th Reg.		14.6	14.6	14.6
27th Reg.				
35th Reg.			14.1	14.1
Support				5.9
40th Inf. Div.	-	68.3	0	205.0
160th Reg.		29.0		231.8
223rd Reg.				495.2
224th Reg.		29.0		
Support		100.1		100.1
45th Inf. Div.	26.9	64.6	21.5	56.6
179th Reg.	79.0	184.4	26.3	
180th Reg.	55.9	69.9	41.9	195.6
279th Reg.		13.1	26.1	78.3
Support		27.2	6.8	6.8
Misc. Eighth Army Units	1.1	2.9	0.4	2.2
Total	4.8	16.2	4.0	12.6

RESTRICTED
Security Information

APPENDIX TABLE 2d

WEEKLY COLD INJURY RATE (PER 1000 PER ANNUM) FOR DIVISIONS, REGIMENTS AND SUPPORT ELEMENTS, UNITED STATES EIGHTH ARMY KOREA, FEBRUARY 1952

Unit	2 Feb. 52	9 Feb. 52	16 Feb. 52	23 Feb. 52
2nd Inf. Div.	2.9	5.8	0	2.9
9th Reg.				14.7
23rd Reg.		31.1		
38th Reg.				
Support	6.8			
3rd Inf. Div.	0	5.2	2.8	2.8
7th Reg.				
15th Reg.		14.1	14.1	
65th Reg.				12.7
Support		6.2		
7th Inf. Div.	30.2	43.9	2.7	24.7
17th Reg.	13.9	83.4		
31st Reg.	24.9	62.2		
32nd Reg.	110.8	55.4	13.9	124.7
Support		7.2		
24th Inf. Div.	18.2	50.0	9.1	0
5th Reg.	30.7	107.5	15.4	
19th Reg.				
21st Reg.				
Support		88.9		
25th Inf. Div.	7.9	0	0	31.5
14th Reg.				12.1
27th Reg.				
35th Reg.	13.2			145.1
Support	13.6			
40th Inf. Div.	25.9	80.5	8.6	20.1
160th Reg.	60.3	103.6		60.3
223rd Reg.	45.1	240.3	15.0	15.0
224th Reg.	20.1	40.1	20.1	
Support		6.7	6.7	6.7
45th Inf. Div.	42.1	72.9	0	19.6
179th Reg.		40.5		13.5
180th Reg.	162.5	121.9		
279th Reg.	13.5	53.8		26.9
Support	14.9	74.3		29.7
Misc. Eighth Army Units	2.2	2.9	0.4	1.1
Total	9.9	19.2	1.4	8.3

RESTRICTED
Security Information

RESTRICTED
Security Information

APPENDIX TABLE 3e

WEEKLY COLD INJURY RATE (PER 1000 PER ANNUM) FOR DIVISIONS, REGIMENTS AND SUPPORT ELEMENTS, UNITED STATES EIGHTH ARMY KOREA, MARCH 1952

Unit	1 Mar. 52	8 Mar. 52	15 Mar. 52	22 Mar. 52	29 Mar. 52
1st Mar. Div.	0	0	0	0	0
2nd Inf. Div.	0	0	2.9	0	0
9th Reg.					
23rd Reg.			14.5		
38th Reg.					
Support					
3rd Inf. Div.	0	0	0	0	0
7th Reg.					
15th Reg.					
65th Reg.					
Support					
7th Inf. Div.	5.6	2.8	0	0	0
17th Reg.					
31st Reg.					
32nd Reg.	28.7	14.3			
Support					
24th Inf. Div.	9.1	-	-	-	-
5th Reg.					
19th Reg.					
21st Reg.					
Support	22.2				
25th Inf. Div.	19.0	2.7	0	2.7	0
14th Reg.	11.5				
27th Reg.					
35th Reg.	71.6	14.3		14.3	
Support	7.1				
40th Inf. Div.	2.7	0	0	0	0
160th Reg.					
223rd Reg.					
224th Reg.	15.1				
Support					
45th Inf. Div.	11.1	5.5	0	0	0
179th Reg.	13.6	13.6			
180th Reg.	14.1				
279th Reg.	27.5				
Support		6.9			
Misc. Eighth Army Units	0.4	0	0	0	0
Total	3.2	0.8	0.2	0.2	0

RESTRICTED
Security Information

APPENDIX TABLE 3a

RESTRICTED
Security Information

MONTHLY BATTLE CASUALTY RATES FOR DIVISIONS, REGIMENTS AND SUPPORT ELEMENTS, UNITED STATES EIGHTH ARMY KOREA, 1951-52

Monthly Rate per 1000 per Annum							
Unit	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March
1st Cav. Div.	171.0	1852.0	317.0	8.1	0	0	0
5th Reg.	331.1	4646.8	58.7	0	-	-	-
7th Reg.	474.8	3460.4	1081.4	0	-	-	-
8th Reg.	69.0	1251.6	373.0	41.0	-	-	-
Support	9.3	62.9	11.3	0	-	-	-
1st Mar. Div.	0	0	91.0	39.0	83.0	0	0
2nd Inf. Div.	1291.4	761.2	3.2	32.9	46.6	44.3	38.5
9th Reg.	3718.1	1662.3	0	20.9	38.4	84.2	91.0
23rd Reg.	2840.8	1108.8	0	81.4	62.6	35.0	21.7
38th Reg.	1875.3	1651.0	0	69.8	183.2	78.0	69.7
Support	33.7	53.2	6.5	0	0.9	13.6	8.7
3rd Inf. Div.	182.0	332.3	225.0	121.2	54.8	49.8	28.2
7th Reg.	352.2	469.8	179.5	139.9	21.5	0	75.1
15th Reg.	189.2	987.4	592.3	134.7	66.0	151.9	66.0
65th Reg.	413.3	263.6	3.7	374.2	202.2	92.1	0
Support	4.5	24.6	212.5	2.9	1.2	.3	1.6
7th Inf. Div.	589.3	151.4	255.7	133.3	230.9	114.0	3.5
17th Reg.	2048.6	45.3	293.5	340.6	126.2	156.4	0
31st Reg.	613.6	327.1	490.7	104.2	222.6	43.5	15.9
32nd Reg.	443.2	390.6	572.2	232.8	174.3	370.6	0
Support	-	-	-	-	-	-	0
24th Inf. Div.	16.4	905.9	190.8	109.3	37.4	-	-
5th Reg.	6.6	923.1	252.8	199.6	21.5	-	-
19th Reg.	80.0	2202.6	595.9	183.1	56.4	-	-
21st Reg.	0	1761.2	316.1	219.1	38.2	-	-
Support	2.6	68.1	19.0	2.5	8.7	-	-
25th Inf. Div.	331.4	195.4	111.5	52.2	1.6	37.4	95.6
14th Reg.	146.6	613.3	83.2	127.6	0	36.4	172.6
27th Reg.	844.2	155.6	332.8	72.6	0	112.5	0
35th Reg.	759.9	549.8	261.5	64.9	8.5	36.3	254.2
Support	69.3	-	-	-	0	0	17.6
40th Inf. Div.	-	-	-	-	58.1	67.6	35.5
160th Reg.	-	-	-	-	92.7	57.3	60.2
223rd Reg.	-	-	-	-	49.5	78.9	26.4
224th Reg.	-	-	-	-	-	260.8	49.2
Support	-	-	-	-	0	3.4	23.4
45th Inf. Div.	-	-	-	9.2	85.2	26.6	47.0
179th Reg.	-	-	-	0	208.1	3.3	81.6
180th Reg.	-	-	-	39.0	92.2	47.4	95.4
279th Reg.	-	-	-	0	117.5	77.4	55.0
Support	-	-	-	1.7	4.1	0	1.7
Misc. Eighth Army Units	6.6	9.0	3.8	4.1	2.3	-	6.5
Total	229.5	350.0	92.7	37.8	29.1	27.5	23.6

RESTRICTED
Security Information

APPENDIX TABLE 3b

MONTHLY NON-BATTLE INJURY RATES (EXCLUSIVE OF COLD INJURIES) FOR DIVISIONS, REGIMENTS AND SUPPORT ELEMENTS, UNITED STATES EIGHTH ARMY KOREA, 1951-52

	Monthly Rate per 1000 per Annum						
Unit	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March
1st Cav. Div.	95.8	119.1	110.9	46.0	-	-	-
5th Reg.	44.4	113.1	124.0	66.6	-	-	-
7th Reg.	185.0	209.6	104.4	77.1	-	-	-
8th Reg.	96.6	83.6	103.4	71.8	-	-	-
Support	79.1	95.7	110.7	-	-	-	-
1st Mar. Div.	-	-	80.0	81.0	74.0	-	-
2nd Inf. Div.	152.9	174.4	120.0	107.2	123.9	118.5	103.1
9th Reg.	486.6	332.5	265.5	173.8	101.6	150.2	118.7
23rd Reg.	194.5	204.3	108.8	111.9	330.0	46.7	130.4
38th Reg.	134.4	129.2	130.7	69.8	150.7	177.2	99.0
Support	69.7	51.2	68.8	92.2	60.1	107.1	85.0
3rd Inf. Div.	129.6	135.0	130.8	135.7	110.6	95.0	79.6
7th Reg.	179.4	225.0	-	276.5	174.5	113.8	125.2
15th Reg.	146.8	132.2	-	97.7	104.5	98.9	91.6
65th Reg.	182.1	172.5	-	244.8	176.9	136.5	81.2
Support	77.3	79.8	-	44.7	43.6	64.3	52.5
7th Inf. Div.	119.0	109.2	151.3	201.3	130.7	126.4	103.2
17th Reg.	120.7	88.1	146.8	319.1	90.5	100.8	96.4
31st Reg.	133.1	153.6	241.9	198.4	151.6	139.9	82.9
32nd Reg.	183.9	90.8	232.7	253.3	195.7	183.6	161.2
Support	83.1	102.4	78.6	120.9	104.4	102.2	88.9
24th Inf. Div.	100.5	151.9	136.9	110.4	67.2	-	-
5th Reg.	78.9	222.7	193.6	207.3	27.6	-	-
19th Reg.	166.9	218.9	297.9	129.3	87.8	-	-
21st Reg.	142.4	151.6	119.5	152.6	124.1	-	-
Support	67.5	93.7	81.9	59.0	-	-	-
25th Inf. Div.	112.6	127.3	123.2	148.5	88.8	130.0	123.4
14th Reg.	76.8	152.5	181.6	124.1	113.7	142.5	115.1
27th Reg.	115.7	145.5	142.1	193.5	50.0	43.0	39.1
35th Reg.	104.7	149.7	158.3	97.3	42.4	115.5	196.9
Support	84.9	123.8	127.9	164.8	113.7	115.3	134.1
40th Inf. Div.	-	-	-	-	112.7	155.3	115.8
160th Reg.	-	-	-	-	69.5	156.8	155.7
223rd Reg.	-	-	-	-	198.1	244.1	102.0
224th Reg.	-	-	-	-	-	90.3	155.3
Support	-	-	-	-	160.2	135.4	89.4
45th Inf. Div.	-	-	-	15.7	153.0	191.3	91.2
179th Reg.	-	-	-	3.3	229.1	273.6	132.7
180th Reg.	-	-	-	66.0	181.7	196.4	88.3
279th Reg.	-	-	-	-	91.4	208.5	75.7
Support	-	-	-	1.3	131.7	133.8	79.4
Misc. Eighth Army Units	101.9	81.0	70.9	100.2	83.4	33.7	107.7
Total	110.6	105.2	101.6	113.6	98.8	81.2	105.4

RESTRICTED
Security Information

APPENDIX TABLE 4a

COMPARISON OF DIVISION DISTRIBUTION OF A SAMPLE OF 275 CASES OF FROSTBITE SELECTED AT RANDOM FOR PURPOSES OF QUARTERMASTER SURVEY WITH DISTRIBUTION OF TOTAL CASES OF FROSTBITE KOREA, 1951-52

Division	Quartermaster Sample		Total Cases	
	No.	%	No.	%
1st Cav.	0	-	9	1.3
1st Mar.	5	1.8	10	1.4
2nd Inf.	7	2.5	24	3.4
3rd Inf.	28	10.2	98	13.7
7th Inf.	70	25.5	200	27.9
24th Inf.	26	9.5	76	10.6
25th Inf.	18	6.5	47	6.6
40th Inf.	29	10.5	64	8.9
45th Inf.	72	26.2	125	17.5
Misc. Eighth Army Units	17	6.2	55	7.7
No Data	3	1.1	8	1.1
Total	275	100.0	716	100.1

Chi square = 15.50 df = 10 P >.10

APPENDIX TABLE 4b

COMPARISON OF DISTRIBUTION BY RACE IN A SAMPLE OF 275 CASES OF FROSTBITE SELECTED AT RANDOM FOR PURPOSES OF QUARTERMASTER SURVEY WITH DISTRIBUTION OF TOTAL CASES OF FROSTBITE KOREA, 1951-52

Race	Quartermaster Sample		Total Cases	
	No.	%	No.	%
White	169	61.4	417	58.2
Negro	102	37.1	291	40.6
Mongolian	4	1.5	8	1.1
Total	275	100.0	716	99.9

Chi square = 1.144 df = 2 P >.50

RESTRICTED
Security Information

APPENDIX TABLE 5

COMPARISON OF DIVISIONAL MEAN AGES BETWEEN 700 FROSTBITE CASES AND 455 BUNKER-MATE CONTROLS KOREA, 1951-52

Division	Cases			Controls		
	No.	Mean Age In Years	S.D.	No.	Mean Age In Years	S.D.
1st Cav.	9	21.3	± 2.31	0	-	-
1st Mar.	10	19.6	± 2.00	0	-	-
2nd Inf.	24	21.5	± 2.76	0	-	-
3rd Inf.	96	22.4	± 2.67	57	22.6	± 1.95
7th Inf.	198	21.7	± 2.16	162	22.3	± 2.61
24th Inf.	75	21.1	± 2.[illegible]4	47	21.7	± 1.97
25th Inf.	46	21.7	± 2.88	14	21.8	± 1.69
40th Inf.	62	22.1	± 2.23	58	22.8	± 2.10
45th Inf.	125	22.2	± [illegible]77	117	23.0	± 2.79
Misc. Eighth Army Units	55	22.4	± [illegible]06	0	-	-
Total	700	21.9	± 2.55	455	22.5	± 2.47

APPENDIX TABLE 6a

RELATION OF AGE TO DEGREE OF INJURY AMONG 336 WHITE CASES
OF FROSTBITE OF THE FEET
KOREA, 1951-52

Age Last Birthday (In Years)	Degree of Injury									
	First		Second		Third		Fourth		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%
17	2	1.3	1	0.9	0	-	0	-	3	0.9
18	12	7.5	6	5.6	3	5.4	2	14.3	23	6.8
19	19	11.9	8	7.5	5	8.9	0	-	32	9.5
20	17	10.7	5	4.7	6	10.7	0	-	28	8.3
21	29	18.2	18	16.8	9	16.1	4	28.6	60	17.9
22	24	15.1	21	19.6	15	26.8	4	28.6	64	19.0
23	31	19.5	28	26.2	10	17.9	2	14.3	71	21.1
24	12	7.5	9	8.4	3	5.4	2	14.3	26	7.7
25	8	5.0	2	1.9	0	-	0	-	10	3.0
26	0	-	4	3.7	2	3.6	0	-	6	1.9
27	1	0.6	0	-	0	-	0	-	1	0.3
28	1	0.6	0	-	0	-	0	-	1	0.3
29	1	0.6	2	1.9	1	1.8	0	-	4	1.2
30	2	1.3	2	1.9	0	-	0	-	4	1.2
31	0	-	1	0.9	0	-	0	-	1	0.3
36	0	-	0	-	1	1.8	0	-	1	0.3
38	0	-	0	-	1	1.8	0	1	1	0.3
Total	159	99.8	107	100.0	56	100.2	14	100.1	336	100.0
Mean (In Years)	21.6		22.2		22.2		21.6		21.9	
S.D.	± 2.34		± 2.52		± 3.48		± 1.90		± 2.62	

APPENDIX TABLE 6b

RELATION OF AGE TO DEGREE OF INJURY AMONG 237 NEGRO CASES
OF FROSTBITE OF THE FEET
KOREA, 1951-52

Age Last Birthday (In Years)	Degree of Injury									
	First		Second		Third		Fourth		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%
17	2	2.4	0	-	2	2.8	1	7.7	5	2.1
18	2	2.4	5	7.4	4	5.6	2	15.4	13	5.5
19	10	11.9	6	8.8	7	9.7	0	-	23	9.7
20	7	8.3	9	13.2	13	18.1	0	-	29	12.2
21	17	20.2	17	25.0	21	29.2	5	38.5	60	25.3
22	19	22.6	12	17.6	12	16.7	5	38.5	48	20.3
23	14	16.7	8	11.8	2	2.8	0	-	24	10.1
24	3	3.6	7	10.3	5	6.9	0	-	15	6.3
25	4	4.8	0	-	2	2.8	0	-	6	2.5
26	3	3.6	3	4.4	2	2.8	0	-	8	3.4
27	1	1.2	1	1.5	2	2.8	0	-	4	1.7
30	1	1.2	0	-	0	-	0	-	1	0.4
32	1	1.2	0	-	0	-	0	-	1	0.4
Total	84	100.1	68	100.0	72	100.2	13	100.1	237	99.9
Mean (In Years)	21.9		21.5		21.2		20.6		21.5	
S.D.	± 2.47		± 2.03		± 2.13		± 1.83		± 2.23	

RESTRICTED
Security Information

APPENDIX TABLE 6c

RELATION OF DEGREE OF INJURY TO AGE AMONG 56 WHITE CASES
OF FROSTBITE OF THE HANDS ALONE
KOREA, 1951-52

Age Last Birthday (In Years)	Degree of Injury									
	First		Second		Third		Fourth		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%
18	1	5.0	1	3.2	0	-	0	-	2	3.6
19	0	-	4	12.5	0	-	0	-	4	7.1
20	1	5.0	6	19.4	0	-	0	-	7	12.5
21	2	10.0	6	19.4	0	-	0	-	8	14.3
22	3	15.0	5	16.1	0	-	2	50.0	10	17.9
23	4	20.0	5	16.1	0	-	1	25.0	10	17.9
24	4	20.0	2	6.5	0	-	1	25.0	7	12.5
25	1	5.0	0	0.0	0	-	0	-	1	1.8
26	2	10.0	0	0.0	1	100.0	0	-	3	5.4
27	1	5.0	0	0.0	0	-	0	-	1	1.8
28	0	-	1	3.2	0	-	0	-	1	1.8
33	0	-	1	3.2	0	-	0	-	1	1.8
35	1	5.0	0	0.0	0	-	0	-	1	1.8
Total	20	100.0	31	99.6	1	100.0	4	100.0	56	100.2
Mean (In Years)	23.7		21.7		26.0		22.8		22.6	
S.D.	± 3.51		± 2.84		—		± 1.11		± 3.08	

RESTRICTED
Security Information

RESTRICTED
Security Information

APPENDIX TABLE 6d

RELATION OF DEGREE OF INJURY TO AGE AMONG 44 NEGRO CASES
OF FROSTBITE OF THE HANDS ALONE
KOREA, 1951-52

Age Last Birthday (In Years)	Degree of Injury									
	First		Second		Third		Fourth		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%
18	0	-	2	7.4	0	-	0	-	2	4.5
19	1	12.5	2	7.4	3	42.9	0	-	6	13.6
20	2	25.0	2	7.4	0	-	0	-	4	9.1
21	1	12.5	2	7.4	0	-	0	-	3	6.8
22	3	37.5	6	22.2	4	57.1	2	100.0	15	34.1
23	1	12.5	6	22.2	0	-	0	-	7	15.9
24	0	-	4	14.8	0	-	0	-	4	9.1
25	0	-	3	11.1	0	-	0	-	3	6.8
Total	8	100.0	27	99.9	7	100.0	2	100.0	44	99.9
Mean (In Years)	21.1		22.1		20.7		22.0		21.7	
S.D.	± 1.45		± 2.08		± 1.73		——		± 1.85	

RESTRICTED
Security Information

RESTRICTED
Security Information

APPENDIX TABLE 7a

DISTRIBUTION OF 704 CASES OF FROSTBITE ACCORDING TO DIVISION AND RANK
KOREA, 1951-52

Rank	1st Cav. Div.		1st Mar. Div.		2nd Inf. Div.		3rd Inf. Div.		7th Inf. Div.	
	No.	%	No.	%	No.	%	No.	%	No.	%
Private	4	44.0	1	10.0	6	25.0	33	34.0	76	38.2
Pfc.	5	55.5	5	50.0	7	29.2	36	37.1	79	39.7
Cpl.	0	-	4	40.0	8	33.3	19	19.6	32	16.1
Sgt.	0	-	0	-	3	12.5	8	8.2	11	5.5
Co. Gd. Off.	0	-	0	-	0	-	1	1.0	1	0.5
Total	9	99.9	10	100.0	24	100.0	97	99.9	199	100.0

Rank	24th Inf. Div.		25th Inf. Div.		40th Inf. Div.		45th Inf. Div.		Misc. Eighth Army Units	
	No.	%	No.	%	No.	%	No.	%	No.	%
Private	24	31.6	19	41.3	10	15.9	39	31.2	19	34.5
Pfc.	38	50.0	16	34.8	30	47.6	46	36.8	16	29.1
Cpl.	8	10.5	6	13.0	16	25.4	15	12.0	15	27.3
Sgt.	6	7.9	5	10.9	6	9.5	24	19.2	3	5.5
Co. Gd. Off.	0	-	0	-	1	1.6	1	0.8	2	3.6
Total	76	100.0	46	100.0	63	100.0	125	100.0	55	100.0

RESTRICTED
Security Information

APPENDIX TABLE 7b

DISTRIBUTION OF 455 BUNKER-MATE CONTROLS ACCORDING TO DIVISION AND RANK
KOREA, 1951-52

Rank	1st Cav. Div.		1st Mar. Div.		2nd Inf. Div.		3rd Inf. Div.		7th Inf. Div.	
	No.	%	No.	%	No.	%	No.	%	No.	%
Private	0	-	0	-	0	-	13	22.8	19	11.7
Pfc.	0	-	0	-	0	-	24	42.1	70	43.2
Cpl.	0	-	0	-	0	-	8	14.0	41	25.3
Sgt.	0	-	0	-	0	-	12	21.0	31	19.1
Co. Gd. Off.	0	-	0	-	0	-	0	-	1	0.6
Total	0	-	0	-	0	-	57	99.9	162	99.9

Rank	24th Inf. Div.		25th Inf. Div.		40th Inf. Div.		45th Inf. Div.		Misc. Eighth Army Units	
	No.	%	No.	%	No.	%	No.	%	No.	%
Private	6	12.8	3	21.4	3	5.2	14	12.0	0	-
Pfc.	21	44.7	5	[illegible]	15	25.9	33	28.2	0	-
Cpl.	12	25.5	3	21.4	16	27.6	33	28.2	0	-
Sgt.	8	17.0	3	21.4	22	37.9	37	31.6	0	-
Co. Gd. Off.	0	-	0	-	2	3.4	0	-	0	-
Total	47	100.0	14	99.9	58	100.0	117	100.0	0	-

APPENDIX TABLE 8

DISTRIBUTION OF 700 CASES OF FROSTBITE AND 455 BUNKER-MATE CONTROLS
ACCORDING TO RANK AND INTENSITY OF ACTIVITY DURING EXPOSURE
KOREA, 1951-52

	ACTIVITY	CASES		CONTROLS	
		Group I * Ranks	Group II ** Ranks	Group I * Ranks	Group II ** Ranks
Light Activity	Sleeping	27	3	0	1
	Lying, sitting or kneeling with no movement	62	6	33	18
	Lying, sitting or kneeling with little movement	171	23	101	39
	Standing with no movement	16	3	11	2
	Standing with little movement	177	21	41	5
	Subtotal	453	56	186	65
Heavy Activity	Lying, sitting or kneeling with considerable movement	15	2	57	15
	Standing with considerable movement	35	3	51	12
	Walking with infrequent breaks	34	5	19	10
	Walking with frequent breaks	69	8	26	14
	Subtotal	173	18	153	51
	Total	626	74	339	116

* Group I Ranks = Pvt. thru Corporal
** Group II Ranks = Sgt. thru Field Grade Officer

RESTRICTED
Security Information

APPENDIX TABLE 9

DISTRIBUTION OF 694 CASES OF FROSTBITE ACCORDING TO RACE AND UNIT
KOREA, 1951-52

Unit	Total Cases	White Cases		Negro Cases		% Negroes in Unit
		No.	%	No.	%	
1st Cav. Div.						
5th Reg.	4	3	75.0	1	25.0	7.2
7th Reg.	2	2	100.0	0	-	14.7
8th Reg.	3	1	33.3	2	66.7	5.5
1st Mar. Div.						
1st Reg.	1	1	100.0	0	-	-
5th Reg.	7	6	85.7	1	14.3	-
Support	1	1	100.0	0	-	-
2nd Inf. Div.						
9th Reg.	4	3	75.0	1	25.0	6.8
23rd Reg.	3	0	-	3	100.0	8.2
38th Reg.	10	7	70.0	3	30.0	6.7
Support	6	3	50.0	3	50.0	-
3rd Inf. Div.						
7th Reg.	34	13	38.2	21	61.8	17.1
15th Reg.	17	9	52.9	8	47.1	17.7
65th Reg.	38	25	65.8	13	34.2	16.3
Support	6	3	50.0	3	50.0	-
7th Inf. Div.						
17th Reg.	132	83	62.9	49	37.1	12.0
31st Reg.	22	11	50.0	11	50.0	11.6
32nd Reg.	38	19	50.0	19	50.0	12.5
Support	4	2	50.0	2	50.0	-
24th Inf. Div.						
5th Reg.	34	10	29.4	24	70.6	15.0
19th Reg.	8	4	50.0	4	50.0	16.1
21st Reg.	24	1	4.2	23	95.8	16.0
Support	10	6	60.0	4	40.0	-
25th Inf. Div.						
14th Reg.	6	0	-	6	100.0	10.4
27th Reg.	1	1	100.0	0	-	8.9
35th Reg.	29	10	34.5	19	65.5	8.6
Support	9	3	33.3	6	66.7	-
40th Inf. Div.						
160th Reg.	28	24	85.7	4	14.3	6.1
223rd Reg.	23	22	95.7	1	4.3	4.6
224th Reg.	6	5	83.3	1	16.7	4.9
Support	5	5	100.0	0	-	-
45th Inf. Div.						
179th Reg.	30	26	86.7	4	13.3	1.5
180th Reg.	53	43	81.1	10	18.9	1.6
279th Reg.	18	13	72.2	5	27.8	1.5
Support	23	22	95.7	1	4.3	-
Misc. Eighth Army Units	55	22	40.0	33	60.0	-
Total	694	409	58.9	285	41.1	14.1

RESTRICTED
Security Information

RESTRICTED
Security Information

APPENDIX TABLE 10

COMPARISON OF MEAN AGE AT TIME OF INJURY BETWEEN NEGROES AND WHITES FOR FROSTBITE CASES, EPIDEMIOLOGIC CONTROLS AND PRE-EXPOSURE CONTROLS
KOREA, 1951-52

Race	Cases			Epidemiologic Controls			Pre-Exposure Controls		
	No.	Mean Age in Years	S.D.	No.	Mean Age in Years	S.D.	No.	Mean Age in Years	S.D.
White	409	22.0	± 2.68	404	22.5	± 2.53	1301	21.7	± 2.71
Negro	287	21.6	± 2.20	37	21.9	± 1.49	277	21.6	± 2.14
TOTAL	696	21.8	± 2.49	441	22.5	± 2.47	1578	21.7	± 2.62
	t = 2.352 P <.02			t = 2.466 P <.01			t = 0.807 P >.40		

APPENDIX TABLE 11

COMPARISON OF 693 CASES AND 441 BUNKER-MATE CONTROLS WITH RESPECT TO RACE AND RANK
KOREA, 1951-52

Rank	White				Negro			
	Cases		Controls		Cases		Controls	
	No.	%	No.	%	No.	%	No.	%
Private	110	27.0	43	10.6	117	40.9	14	37.8
Pfc.	164	40.3	148	36.6	110	38.5	17	45.9
Cpl.	73	17.9	104	25.7	47	16.4	4	10.8
Sgt.	54	13.3	106	26.2	12	4.2	2	5.4
Co. Gd. Officer	6	1.5	3	0.7	0	-	0	-
TOTAL	407	100.0	404	99.8	286	100.0	37	99.9
Chi square	53.325				1.330			
P	<.001				>.70			
White cases vs Negro cases: Chi square = 29.616 df = 4 P <.001								

RESTRICTED
Security Information

RESTRICTED
Security Information

APPENDIX TABLE 12

DISTRIBUTION OF 692 CASES OF FROSTBITE AND 437 EPIDEMIOLOGIC CONTROLS ACCORDING TO RACE AND LOCALE OF RESIDENCE
KOREA, 1951-52

	White		Negro	
	Rural	Urban	Rural	Urban
Cases	101	306	54	231
Epidemiologic Controls	97	303	5	32
TOTAL	198	609	59	263

Comparison	Chi square	P
White cases vs White epidemiologic controls	0.035	>.80
Negro cases vs Negro epidemiologic controls	0.334	>.50
White cases vs Negro cases	3.321	>.05
White controls vs Negro controls	1.624	>.20

RESTRICTED
Security Information

RESTRICTED
Security Information

APPENDIX TABLE 13

DISTRIBUTION OF 683 CASES AND 440 CONTROLS ACCORDING TO RACE
AND LENGTH OF TIME IN KOREA
KOREA, 1951-52

Days in Korea	White				Negro			
	Cases		Controls		Cases		Controls	
	No.	%	No.	%	No.	%	No.	%
1-30	73	18.2	80	19.9	32	11.3	3	8.1
31-60	102	25.4	71	17.6	35	12.4	3	8.1
61-90	62	15.5	65	16.1	44	15.6	9	24.3
91-120	36	9.0	42	10.4	40	14.2	3	8.1
121-150	36	9.0	12	3.0	35	12.4	5	13.5
151-180	25	6.2	36	8.9	20	7.1	4	10.8
181-210	12	3.0	35	8.7	13	4.6	2	5.4
211-240	53	13.2	30	7.4	61	21.6	7	18.9
Over 241	2	0.5	32	7.9	2	0.7	1	2.7
TOTAL	401	100.0	403	99.9	282	99.9	37	99.9
MEAN	93.7		93.9		120.9		124.2	
S.D.	± 69.99		± 69.15		± 52.83		± 67.88	
White cases vs Negro cases: t = 5.779 P <.001								

RESTRICTED
Security Information

RESTRICTED
Security Information

APPENDIX TABLE 14

RACIAL COMPARISON OF 672 CASES OF FROSTBITE AND 442 CONTROLS WITH RESPECT TO NUMBER OF DAYS IN COMBAT
KOREA, 1951-52

Days in Combat	White				Negro			
	Cases		Controls		Cases		Controls	
	No.	%	No.	%	No.	%	No.	%
0-15	121	30.4	106	26.2	69	25.2	5	13.5
16-30	89	22.4	73	18.0	35	12.8	11	29.7
31-45	47	11.8	54	13.3	18	6.6	4	10.8
46-60	29	7.3	31	7.7	21	7.7	0	-
61-75	17	4.3	17	4.2	18	6.6	2	5.4
76-90	16	4.0	20	4.9	23	8.4	6	16.2
91-105	17	4.3	19	4.7	15	5.5	1	2.7
106-120	13	3.4	30	7.4	20	7.3	3	8.1
121-135	49	12.3	55	13.6	55	20.1	5	13.5
TOTAL	398	100.2	405	100.0	274	100.2	37	99.9
MEAN (days)	46.2		53.0		62.6		58.7	
S.D.	± 41.78		± 43.74		± 46.49		± 42.54	
White cases vs Negro cases: t = 4.704 P <.001								

RESTRICTED
Security Information

APPENDIX TABLE 15

RACIAL COMPARISON OF 652 CASES OF FROSTBITE AND 442 CONTROLS WITH RESPECT TO NUMBER OF DAYS IN COMBAT WITHOUT REST
KOREA, 1951-52

Days in Combat Without Rest	White				Negro			
	Cases		Controls		Cases		Controls	
	No.	%	No.	%	No.	%	No.	%
0-4	100	25.3	81	20.0	91	34.6	11	30.6
5-9	82	20.8	100	24.6	42	16.0	5	13.9
10-14	54	13.7	116	28.6	24	9.1	9	25.0
15-19	40	10.1	60	14.8	19	7.2	10	27.7
20-24	17	4.3	15	3.7	13	4.9	1	2.8
25-29	14	3.5	9	2.2	6	2.3	0	-
30-34	36	9.1	17	4.2	14	5.3	0	-
35-39	11	2.8	2	0.5	2	0.8	0	-
40-44	41	10.4	6	1.5	52	19.8	0	-
TOTAL	395	100.0	406	100.1	263	100.0	36	100.0
MEAN (days)	16.0		12.1		16.6		10.4	
S.D.	± 13.42		± 8.45		± 15.41		± 6.28	

White cases vs Negro cases: t = 0.515 P >.60

RESTRICTED
Security Information

APPENDIX TABLE 16

COMPARISON OF 657 FROSTBITE CASES, 436 EPIDEMIOLOGIC CONTROLS
AND 1547 PRE-EXPOSURE CONTROLS WITH RESPECT TO RACE
AND HISTORY OF PREVIOUS COLD INJURY
KOREA, 1951-52

Previous Cold Injury	White						Negro					
	Cases		Controls*		Pre-Exp. Controls		Cases		Controls*		Pre-Exp. Controls	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
None	302	78.2	353	88.2	1109	87.1	225	83.4	33	91.7	240	87.6
Frostbite	80	20.7	38	9.5	148	11.6	45	16.6	0	-	33	12.0
Trenchfoot	1	0.3	2	0.5	5	0.4	0	-	0	-	0	-
Chilblains	3	0.8	7	1.8	11	0.9	0	-	3	8.3	1	0.4
TOTAL	386	100.0	400	100.0	1273	100.0	271	100.0	36	100.0	274	100.0
Chi square	-		20.652		22.035		-		28.656		3.348	
df	-		3		3		-		2		2	
P	-		<.001		<.001		-		<.001		>.10	
White cases vs Negro cases: Chi square = 5.413 df = 3 P >.10												

*From Epidemiologic s[illegible]vey

RESTRICTED
Security Information

RESTRICTED
Security Information

APPENDIX TABLE 17

COMPARISON OF 708 FROSTBITE CASES, 433 EPIDEMIOLOGIC CONTROLS AND 1130 PRE-EXPOSURE CONTROLS WITH REFERENCE TO RACE AND HISTORY OF PREVIOUS ILLNESS KOREA, 1951-52

Previous Illness	White						Negro					
	Cases		Controls*		Pre-Exp. Controls		Cases		Controls*		Pre-Exp. Controls	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
None	334	79.9	286	71.0	577	61.3	223	76.9	17	56.7	112	59.3
Fevers	3	0.7	3	0.7	23	2.4	5	1.7	1	3.3	6	3.2
Pneumonia	59	14.1	72	17.9	229	24.3	35	12.1	6	20.0	44	23.3
Jaundice	0	-	11	2.7	36	3.8	1	0.3	0	-	3	1.6
Malaria	19	4.5	20	5.0	53	5.6	13	4.5	3	10.0	12	6.3
Raynauds	3	0.7	1	0.2	0	-	0	-	0	-	0	—
Hematuria	0	-	8	2.0	15	1.6	2	0.7	2	6.7	1	0.5
Syphilis	0	-	2	0.5	8	0.9	11	3.8	1	3.3	11	5.8
TOTAL	418	99.9	403	100.0	941	99.9	290	100.0	30	100.0	189	100.0
White cases vs Negro cases: Chi square = 24.486 df = 7 P <.001												

*From Epidemiologic survey

RESTRICTED
Security Information

RESTRICTED
Security Information

APPENDIX TABLE 18

RACIAL COMPARISON OF EXTENT OF SMOKING AMONG 684 CASES
OF FROSTBITE AND 431 CONTROLS
KOREA, 1951-52

Cigarettes Smoked	Cases				Controls			
	White		Negro		White		Negro	
	No.	%	No.	%	No.	%	No.	%
None	78	19.4	48	17.1	72	18.2	7	20.0
1/2 Pack daily	93	23.1	115	40.9	54	13.6	10	28.6
1 Pack daily	155	38.5	85	30.2	160	40.4	14	40.0
1-1/2 Packs daily	39	9.7	14	5.0	52	13.1	2	5.7
2 Packs daily	30	7.4	16	5.7	43	10.9	1	2.9
Over 2 packs	8	2.0	3	1.1	15	3.8	1	2.9
TOTAL	403	100.1	281	100.0	396	100.0	35	100.1
MEAN	0.8		0.7		1.0		0.8	
S.D.	± 0.61		± 0.54		± 0.67		± 0.57	

White cases vs Negro cases: t = 2.752 P <.01

RESTRICTED
Security Information

APPENDIX TABLE 19

COMPARISON OF 669 FROSTBITE CASES AND 443 CONTROLS WITH RESPECT TO RACE AND NUMBER OF HOURS BETWEEN LAST MEAL AND ONSET OF FROSTBITE KOREA, 1951-52

Number of Hours	White				Negro			
	Cases		Controls		Cases		Controls	
	No.	%	No.	%	No.	%	No.	%
0-6	202	51.1	167	41.1	137	50.0	14	37.8
7-12	137	34.7	165	40.6	92	33.6	17	45.9
13-18	40	10.1	54	13.3	29	10.6	3	8.1
19-24	14	3.5	17	4.2	12	4.3	3	8.1
25-48	2	0.5	1	0.2	3	1.1	0	-
49-72	0	-	1	0.2	1	0.4	0	-
73-96	0	-	0	-	0	-	0	-
97-120	0	-	1	0.2	0	-	0	-
121-144	0	-	0	-	0	-	0	-
TOTAL	395	99.9	406	99.8	274	100.0	37	99.9
MEAN	7.70		8.62		7.88		9.00	
S.D.	± 5.0207		± 5.1468		± 5.2162		± 5.4388	

White cases vs Negro cases: $t = 0.443$ $P > .60$

APPENDIX TABLE 20

COMPARISON OF 683 CASES OF FROSTBITE AND 439 CONTROLS WITH RESPECT TO RACE AND TYPE OF MEAL LAST EATEN KOREA, 1951-52

Type of Meal	White				Negro			
	Cases		Controls		Cases		Controls	
	No.	%	No.	%	No.	%	No.	%
C Ration	163	40.6	184	45.8	112	39.7	16	43.2
B Ration	218	54.4	183	46.8	160	56.7	14	37.8
Individual food packet	5	1.2	0	-	1	0.4	0	-
Native food	1	0.2	0	-	3	1.1	0	-
Less than C Ration or Individual food packet	14	3.5	30	7.5	6	2.1	7	1[illegible].9
TOTAL	401	99.9	402	100.1	282	100.0	37	99.9

White cases vs Negro cases: Chi square = 4.621 df = 4 P >.30

RESTRICTED
Security Information

APPENDIX TABLE 21

DISTRIBUTION OF 572 CASES OF FROSTBITE OF THE FEET AND 444 CONTROLS ACCORDING TO RACE AND TYPE OF FOOTGEAR WORN AT TIME OF INJURY KOREA, 1951-52

Type of Footgear worn	White				Negro			
	Cases		Controls		Cases		Controls	
	No.	%	No.	%	No.	%	No.	%
Boots, service, combat, russet	60	17.7	92	22.6	52	22.3	10	27.0
Boots, service, combat, 2-buckle	81	23.9	50	12.3	55	23.6	13	35.1
Boots, leather, with overshoes	1	0.3	2	0.5	1	0.4	0	-
Shoepac	185	54.6	215	52.8	114	48.9	8	21.6
Boots, combat, rubber, insulated	8	2.4	48	11.8	8	3.4	6	16.2
Shoe, service	2	0.6	0	-	2	0.9	0	-
No footgear	2	0.6	0	-	1	0.4	0	-
TOTAL	339	100.1	407	100.0	233	99.9	37	99.9

White cases vs Negro cases: Chi square = 3.120 df = 6 P >.70

RESTRICTED
Security Information

APPENDIX TABLE 20

COMPARISON OF 683 CASES OF FROSTBITE AND 439 CONTROLS WITH RESPECT TO RACE AND TYPE OF MEAL LAST EATEN
KOREA, 1951-52

Type of Meal	White				Negro			
	Cases		Controls		Cases		Controls	
	No.	%	No.	%	No.	%	No.	%
C Ration	163	40.6	184	45.8	112	39.7	16	43.2
B Ration	218	54.4	188	46.8	160	56.7	14	37.8
Individual food packet	5	1.2	0	-	1	0.4	0	-
Native food	1	0.2	0	-	3	1.1	0	-
Less than C Ration or Individual food packet	14	3.5	30	7.5	6	2.1	7	18.9
TOTAL	401	99.9	402	100.1	282	100.0	37	99.9

White cases vs Negro cases: Chi square = 4.621 df = 4 P >.30

RESTRICTED
Security Information

APPENDIX TABLE 22

COMPARISON OF 559 CASES OF FROSTBITE OF THE FEET AND 443 CONTROLS WITH RESPECT TO RACE AND EXTRA FOOTWEAR CARRIED AT THE TIME OF INJURY KOREA, 1951-52

Extra Footwear Carried	White				Negro			
	Cases		Controls		Cases		Controls	
	No.	%	No.	%	No.	%	No.	%
Extra socks	99	30.0	169	41.6	70	30.7	24	64.9
Extra socks and insoles	116	35.0	196	48.3	70	30.7	7	18.9
No extra socks and no insoles	90	27.2	31	7.6	69	30.3	5	13.5
Extra insoles but no extra socks	5	1.5	4	1.0	3	1.3	0	-
Extra socks but no extra insoles	21	6.3	6	1.5	16	7.0	1	2.7
TOTAL	331	100.0	406	100.0	228	100.0	37	100.0

White cases vs Negro cases: Chi square = 1.420 df = 4 P >.80

RESTRICTED
Security Information

RESTRICTED
Security Information

APPENDIX TABLE 23

RACIAL COMPARISON OF AVERAGE SOCK CHANGE BETWEEN 554 CASES
OF FROSTBITE OF THE FEET AND 443 CONTROLS
KOREA, 1951-52

Average change of socks	White				Negro			
	Cases		Controls		Cases		Controls	
	No.	%	No.	%	No.	%	No.	%
Every day	234	71.3	304	74.9	133	58.8	23	62.2
Every other day	56	17.1	61	15.0	59	26.1	11	29.7
Every third day	20	6.1	16	3.9	17	7.5	3	8.1
Every fourth day	7	2.1	9	2.2	6	2.7	0	-
Every fifth day	4	1.2	1	0.2	1	0.4	0	-
Every sixth day	7	2.1	15	3.7	10	4.4	0	-
TOTAL	328	99.9	406	99.9	226	99.9	37	100.0
MEAN	1.51		1.49		1.73		1.46	
S.D.	± 1.0359		± 1.1091		± 1.2020		± 0.6407	
White cases vs Negro cases: t = 2.234 P <.05								

RESTRICTED
Security Information

APPENDIX TABLE 24

RACIAL COMPARISON OF AVERAGE CHANGE OF INSOLES AMONG 260 CASES
OF FROSTBITE AND 219 CONTROLS WEARING SHOEPACS
KOREA, 1951-52

Average change Of insoles	White				Negro			
	Cases		Controls		Cases		Controls	
	No.	%	No.	%	No.	%	No.	%
Every day	131	78.9	164	78.0	69	73.4	6	66.7
Every other day	26	15.7	32	15.2	17	18.1	2	22.2
Every third day	5	3.0	6	2.9	5	5.3	1	11.1
Every fourth day	0	-	2	1.0	0	-	0	-
Every fifth day	0	-	0	-	0	-	0	-
Every sixth day	4	2.4	6	2.9	3	3.2	0	-
TOTAL	166	100.0	210	100.0	94	100.0	9	100.0
MEAN	1.34		1.38		1.45		1.44	
S.D.	± 0.8751		± 0.9600		± 0.9960		± 0.7700	
White cases vs Negro cases: t = 0.892 P >.30								

APPENDIX TABLE 25

RACIAL COMPARISON OF INTERVAL SINCE LAST CHANGE OF SOCKS BEFORE INJURY
AMONG 565* CASES OF FROSTBITE OF THE FEET AND 445 CONTROLS
KOREA, 1951-52

Last Change of socks Before Injury	White				Negro			
	Cases		Controls		Cases		Controls	
	No.	%	No.	%	No.	%	No.	%
Less than one day	219	66.2	235	57.6	142	60.7	18	48.6
1-2 days	78	23.6	129	31.6	57	24.4	15	40.5
2-3 days	13	3.9	30	7.4	17	7.3	3	8.1
3-4 days	11	3.3	8	2.0	4	1.7	1	2.7
4-5 days	0	-	1	0.2	2	0.9	0	-
Over 5 days	10	3.0	5	1.2	12	5.1	0	-
TOTAL	331	100.0	408	100.0	234	100.1	37	99.9
MEAN	1.06		1.09		1.23		1.15	
S.D.	± 1.0621		± 0.8861		± 1.2541		± 0.7431	
White cases vs Negro cases: t = 1.692 P >.05								

APPENDIX TABLE 26

DISTRIBUTION OF 685 FROSTBITE CASES AND 441 CONTROLS ACCORDING TO RACE AND TYPE OF SOCKGEAR WORN AT TIME OF INJURY
KOREA, 1951-52

Sockgear Worn	White				Negro			
	Cases		Controls		Cases		Controls	
	No.	%	No.	%	No.	%	No.	%
Socks, wool, cushion sole 1 pr.	122	30.2	148	36.6	109	38.8	22	59.5
Socks, wool, cushion sole 2 pr.	23	5.7	22	5.4	21	7.5	4	10.8
Socks, wool, ski 1 pr.	45	11.1	12	3.0	27	9.6	2	5.4
Socks, wool, ski 2 pr.	139	34.4	109	27.0	55	19.6	4	10.8
Socks, wool, ski 3 pr.	1	0.2	5	1.2	2	0.7	0	-
Socks, wool, cushion sole and Socks, wool ski	71	17.6	108	26.8	65	23.1	5	13.5
No socks	3	0.7	0	-	2	0.7	0	-
TOTAL	404	99.9	404	100.0	281	100.0	37	100.0

White cases vs Negro cases: Chi square = 21.050 df = 6 P <.01

RESTRICTED
Security Information

APPENDIX TABLE 27

RACIAL COMPARISON OF CONDITION OF FEET AMONG 678 CASES OF FROSTBITE AND 439 CONTROLS
KOREA, 1951-52

Condition of Feet	White				Negro			
	Cases		Controls		Cases		Controls	
	No.	%	No.	%	No.	%	No.	%
Dry	111	27.9	98	24.4	104	37.1	11	29.7
Wet with sweat	180	45.2	215	53.5	105	37.5	19	51.4
Wet with mud	7	1.8	1	0.2	4	1.4	0	-
Wet with snow	82	20.6	83	20.6	59	21.1	7	18.9
Wet from wading in water	18	4.5	5	1.2	8	2.9	0	-
TOTAL	398	100.0	402	99.9	280	100.0	37	100.0
White cases vs Negro cases: Chi square = 8.163 df = 4 P >.05								

APPENDIX TABLE 28

COMPARISON OF 136 WHITE AND 105 NEGRO CASES OF FROSTBITE OF THE FEET IN LEATHER COMBAT BOOTS WITH RESPECT TO CONDITION OF THE FEET
KOREA, 1951-52

Condition of Feet	Leather Combat Boots					
	White Cases		Negro Cases		Totals	
	No.	%	No.	%	No.	%
Dry	31	22.8	35	33.3	66	27.4
Wet from sweat	20	14.7	14	13.3	34	14.1
Wet from snow and mud	77	56.6	51	48.6	128	53.1
Wet from wading in water	8	5.9	5	4.8	13	5.4
TOTAL	136	100.0	105	100.0	241	100.0
Chi square = 3.360 df = 3 P >.30						

RESTRICTED
Security Information

RESTRICTED
Security Information

APPENDIX TABLE 29

COMPARISON OF 182 WHITE AND 114 NEGRO CASES OF FROSTBITE OF THE FEET IN SHOEPACS WITH RESPECT TO CONDITION OF THE FEET
KOREA, 1951-52

Condition of Feet	Shoepacs					
	White Cases		Negro Cases		Totals	
	No.	%	No.	%	No.	%
Dry	47	25.8	34	29.8	81	27.4
Wet from sweat	117	64.3	71	62.3	188	63.5
Wet from snow and mud	9	4.9	7	6.1	16	5.4
Wet from wading in water	9	4.9	2	1.8	11	3.7
TOTAL	182	99.9	114	100.0	296	100.0
Chi square = 2.504 df = 3 P >.30						

APPENDIX TABLE 30

COMPARISON OF 8 WHITE AND 8 NEGRO CASES OF FROSTBITE OF THE FEET IN INSULATED RUBBER BOOTS WITH RESPECT TO CONDITION OF THE FEET
KOREA, 1951-52

Condition of Feet	Insulated Rubber Boots					
	White Cases		Negro Cases		Totals	
	No.	%	No.	%	No.	%
Dry	1	12.5	1	12.5	2	12.5
Wet from sweat	7	87.5	7	87.5	14	87.5
Wet from snow and mud	0	-	0	-	0	-
Wet from wading in water	0	-	0	-	0	-
TOTAL	8	100.0	8	100.0	16	100.0

RESTRICTED
Security Information

APPENDIX TABLE 31

COMPARISON OF 553 CASES OF FROSTBITE OF THE FEET AND 440 BUNKER-MATE CONTROLS WITH RESPECT TO RACE, TYPE OF FOOTGEAR WORN AND CONDITION OF FEET AT TIME OF INJURY KOREA, 1951-52

Condition of Feet	Type of Boot											
	Leather Combat Boot				Shoepac				Insulated Rubber Boot			
	White		Negro		White		Negro		White		Negro	
	Case	Control	Case	Control	Case	Control	Case	Control	Case	Control	Case	Control
1. Dry	31	32	35	10	47	59	34	1	1	8	1	0
2. Wet from sweat	20	24	14	6	117	152	71	7	7	40	7	6
3. Wet ō snow or mud	77	82	51	7	9	1	7	0	0	0	0	0
4. Wet ō wading in water	8	4	5	0	9	1	2	0	0	0	0	0
Total	136	142	105	23	182	213	114	8	8	48	8	6
Chi square	1.755		4.992		16.328		2.240		0.083		0.810	
df	3		3		3		3		1		1	
P	>.50		>.10		<.001		>.50		>.70		>.30	

RESTRICTED
Security Information

RESTRICTED
Security Information

APPENDIX TABLE 32

RACIAL COMPARISON OF HANDWEAR WORN BY
177 CASES OF FROSTBITE OF THE HANDS
KOREA, 1951-52

Type of Handwear	White		Negro	
	No.	%	No.	%
Mittens, complete	33	31.7	22	30.1
Mitten, shell only	1	1.0	1	1.4
Mitten, inserts only	5	4.8	1	1.4
Gloves, complete	40	38.5	33	45.2
Glove, shell only	0	--	1	1.4
Glove, inserts only	6	5.7	3	4.1
No gloves	19	18.3	12	16.4
TOTAL	104	100.0	73	100.0

Chi square = 3.949 df = 6 P >.50

APPENDIX TABLE 33

RACIAL COMPARISON OF CONDITION OF HANDS AMONG
675 CASES OF FROSTBITE AND 436 CONTROLS
KOREA, 1951-52

Condition of Hands	White				Negro			
	Cases		Controls		Cases		Controls	
	No.	%	No.	%	No.	%	No.	%
Dry	306	77.1	326	81.5	222	79.9	35	97.2
Wet from sweat	32	8.1	47	11.8	21	7.6	1	2.8
Wet from water	54	13.6	27	6.8	34	12.2	0	—
Wet from other liquids	5	1.3	0	--	1	0.4	0	—
TOTAL	397	100.1	400	100.1	278	100.1	36	100.0

White cases vs Negro cases Chi square = 1.956 df = 3 P>.70

RESTRICTED
Security Information

RESTRICTED
Security Information

APPENDIX TABLE 34

RACIAL COMPARISON OF ACTIVITY AT TIME OF INJURY AMONG
686 CASES OF FROSTBITE AND 441 BUNKER-MATE CONTROLS
KOREA, 1951-52

Activity	White				Negro			
	Cases		Controls		Cases		Controls	
	No.	%	No.	%	No.	%	No.	%
Sleeping	12	3.0	1	0.2	17	6.0	0	-
Lying, kneeling, or sitting - no movement	41	10.2	48	11.9	27	9.5	2	5.4
Lying, kneeling, or sitting - little movement	116	28.9	129	31.9	76	26.8	6	16.2
Lying, kneeling, or sitting - considerable movement	7	1.7	60	14.9	9	3.2	9	24.3
Standing with no movement	9	2.2	9	2.2	10	3.5	3	8.1
Standing with little movement	117	29.1	37	9.2	79	27.8	8	21.6
Standing with considerable movement	19	4.7	58	14.4	18	6.3	3	8.1
Walking with infrequent breaks	30	7.5	25	6.2	24	8.5	4	10.8
Walking with frequent breaks	51	12.7	37	9.2	24	8.5	2	5.4
TOTAL	402	100.0	404	100.1	284	100.1	37	99.9
White cases vs Negro cases: Chi square = 10.170 df = 8 P >.20								

RESTRICTED
Security Information

RESTRICTED
Security Information

APPENDIX TABLE 35

COMPARISON OF DURATION OF EXPOSURE FOR 358 WHITE AND 260 NEGRO CASES OF FROSTBITE KOREA, 1951-52

Duration of Exposure in Hours	White		Negro	
	No.	%	No.	%
0-4	140	39.1	114	43.8
4.1-8	99	27.7	74	28.5
8.1-12	64	17.9	41	15.8
12.1-16	31	8.7	15	5.8
16.1-20	8	2.2	2	0.8
20.1-24	16	4.5	14	5.4
TOTAL	358	100.1	260	100.1
MEAN (Hours)	6.8		6.3	
S. D.	± 5.35		± 5.30	
$t = 1.246$ $P > .20$				

APPENDIX TABLE 36

RACIAL COMPARISON OF PERSONAL HYGIENE AMONG 1556 PRE-EXPOSURE CONTROLS KOREA, 1951-52

Personal Hygiene	White		Negro	
	No.	%	No.	%
Excellent	208	16.2	14	5.1
Good	948	74.0	203	73.8
Poor	125	9.8	58	21.1
TOTAL	1281	100.0	275	100.0
Chi square = 43.905 df = 2 $P < .001$				

RESTRICTED
Security Information

RESTRICTED
Security Information

APPENDIX TABLE 37

MEAN SCHOOL GRADE COMPLETED BY 114 FROSTBITE CASES
AND 1343 PRE-EXPOSURE CONTROLS ACCORDING TO RACE
KOREA, 1951-52

Group	White			Negro			t	P
	No.	Mean Grade	S.D.	No.	Mean Grade	S.D.		
Cases	49	10.7	± 1.94	65	10.3	± 1.87	0.911	>.30
Controls	1148	10.2	± 2.17	195	10.0	± 1.96	1.165	>.20

APPENDIX TABLE 38

COMPARISON OF 286 NEGRO CASES OF FROSTBITE
AND 37 NEGRO EPIDEMIOLOGIC CONTROLS WITH
RESPECT TO REGION OF ORIGIN
KOREA, 1951-52

Region of Origin	Negro Cases	Negro Epidemiologic Controls	Total
Northern	24	1	25
Southern	262 (264)	36	298
TOTAL	286	37	323
Chi square = 1.465 P >.20			

RESTRICTED
Security Information

RESTRICTED
Security Information

APPENDIX TABLE 39

COMPARISON OF 286 NEGRO CASES OF FROSTBITE
AND 196 NEGRO PRE-EXPOSURE CONTROLS WITH
RESPECT TO REGION OF ORIGIN
KOREA, 1951-52

Region of Origin	Negro Cases	Negro Pre-Exposure Controls	Total
Northern	24	12	36
Southern	262 (265)	184	446
TOTAL	286	196	432
Chi square = 0.867 P >.50			

APPENDIX TABLE 40

COMPARISON OF 408 WHITE CASES OF FROSTBITE
AND 404 WHITE EPIDEMIOLOGIC CONTROLS WITH
RESPECT TO REGION OF ORIGIN
KOREA, 1951-52

Region of Origin	White Cases	White Epidemiologic Controls	Total
Northern	113	154	267
Southern	295 (273)	250	545
TOTAL	408	404	812
Chi square = 9.992 P <.01			

RESTRICTED
Security Information

RESTRICTED
Security Information

APPENDIX TABLE 41

COMPARISON OF 408 WHITE CASES OF FROSTBITE AND 1146 WHITE PRE-EXPOSURE CONTROLS WITH RESPECT TO REGION OF ORIGIN
KOREA, 1951-52

Region of Origin	White Cases	White Pre-Exposure Controls	Total
Northern	113	437	550
Southern	295 (264)	709	1004
TOTAL	408	1146	1554
Chi square = 14.332 P <.001			

APPENDIX TABLE 42

COMPARISON OF 113 NORTHERN WHITE CASES OF FROSTBITE WITH 152 NORTHERN WHITE CONTROLS IN REGARD TO LOCALE OF RESIDENCE
KOREA, 1951-52

Race and Region of Origin	Type of Residence	
	Rural	Urban
White North Cases	18	95
White North Controls	39	113
TOTAL	57	208
Chi square = 3.082 P >.05		

RESTRICTED
Security Information

APPENDIX TABLE 43

COMPARISON OF 294 SOUTHERN WHITE CASES OF FROSTBITE WITH 248 SOUTHERN WHITE CONTROLS IN REGARD TO LOCALE OF RESIDENCE KOREA, 1951-52

Race and Region of Origin	Type of Residence	
	Rural	Urban
White South Cases	83	211
White South Controls	58	190
TOTAL	141	401
Chi square = 1.640 P >.20		

APPENDIX TABLE 44

COMPARISON OF 261 SOUTHERN NEGRO CASES OF FROSTBITE WITH 36 SOUTHERN NEGRO CONTROLS IN REGARD TO LOCALE OF RESIDENCE KOREA, 1951-52

Race and Region of Origin	Type of Residence	
	Rural	Urban
Negro South Cases	54	207
Negro South Controls	5	31
TOTAL	59	238
Chi square = 0.543 P >.30		

RESTRICTED
Security Information

APPENDIX TABLE 45

COMPARISON OF DEGREE OF INJURY TO LOCALE OF RESIDENCE AMONG 577 CASES OF FROSTBITE OF THE FEET KOREA, 1951-52

Degree	Rural		Urban	
	No.	%	No.	%
First	65	50.4	181	40.4
Second	33	25.6	142	31.7
Third	26	20.1	103	23.0
Fourth	5	3.9	22	4.9
TOTAL	129	100.0	448	100.0
Chi square = 4.148 P >.20				

APPENDIX TABLE 46

COMPARISON OF DEGREE OF INJURY TO LOCALE OF RESIDENCE AMONG 181 CASES OF FROSTBITE OF THE HANDS KOREA, 1951-52

Degree	Rural		Urban	
	No.	%	No.	%
First	15	40.5	69	47.9
Second	17	45.9	58	40.3
Third	1	2.7	11	7.6
Fourth	4	10.8	6	4.2
TOTAL	37	99.9	144	100.0
Chi square = 4.019 P >.20				

RESTRICTED
Security Information

RESTRICTED
Security Information

APPENDIX TABLE 47

DISTRIBUTION OF 336 WHITE CASES OF FROSTBITE OF THE FEET ACCORDING TO DEGREE OF INJURY AND REGION OF ORIGIN KOREA, 1951-52

Degree (Feet)	Climatic Region										Total	
	I		II		III		IV		V			
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
First	8	40.0	33	44.0	66	52.4	40	47.6	11	35.5	158	47.0
Second	8	40.0	24	32.0	41	32.5	23	27.4	11	35.5	107	31.8
Third	2	10.0	16	21.3	17	13.5	17	20.2	5	16.1	57	17.0
Fourth	2	10.0	2	2.7	2	1.6	4	4.8	4	12.9	14	4.2
TOTAL	20	100.0	75	100.0	126	100.0	84	100.0	31	100.0	336	100.0
Chi square = 15.881 P >.10												

APPENDIX TABLE 48

DISTRIBUTION OF 236 NEGRO CASES OF FROSTBITE OF THE FEET ACCORDING TO DEGREE OF INJURY AND REGION OF ORIGIN KOREA, 1951-52

Degree (Feet)	Climatic Region										Total	
	I		II		III		IV		V			
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
First	0	-	6	37.5	36	34.3	33	33.0	8	57.1	83	35.2
Second	0	-	5	31.3	32	30.5	27	27.0	3	21.4	68	28.8
Third	0	-	4	25.0	33	31.4	34	34.0	1	7.1	72	30.5
Fourth	0	-	1	6.3	4	3.8	6	6.0	2	14.3	13	5.5
TOTAL	0	-	16	100.1	105	100.0	100	100.0	14	99.9	236	100.0
Chi square = 10.621 P >.50												

RESTRICTED
Security Information

APPENDIX TABLE 49

DISTRIBUTION OF 104 WHITE CASES OF FROSTBITE OF THE HANDS ACCORDING TO DEGREE OF INJURY AND REGION OF ORIGIN KOREA, 1951-52

Degree (Hands)	Climatic Region										Total	
	I		II		III		IV		V			
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
First	2	66.7	11	57.9	22	59.5	17	47.2	5	55.6	57	54.8
Second	0	-	5	26.3	13	35.1	15	41.7	3	33.3	36	34.6
Third	0	-	2	10.5	1	2.7	0	-	1	11.1	4	3.8
Fourth	1	33.3	1	5.3	1	2.7	4	11.1	0	-	7	6.7
TOTAL	3	100.0	19	100.0	37	100.0	36	100.0	9	100.0	104	99.9
Chi square = 14.041 P >.20												

APPENDIX TABLE 50

DISTRIBUTION OF 74 NEGRO CASES OF FROSTBITE OF THE HANDS ACCORDING TO DEGREE OF INJURY AND REGION OF ORIGIN KOREA, 1951-52

Degree (Hands)	Climatic Region										Total	
	I		II		III		IV		V			
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
First	0	-	3	37.5	11	33.3	11	34.4	1	100.0	26	35.1
Second	0	-	5	62.5	16	48.5	15	46.9	0	-	35	48.6
Third	0	-	0	-	4	12.1	5	15.6	0	-	9	12.2
Fourth	0	-	0	-	2	6.1	1	3.1	0	-	3	4.1
TOTAL	0	-	8	100.0	33	100.0	32	100.0	1	100.0	74	100.0
Chi square = 3.939 P >.90												

RESTRICTED
Security Information

APPENDIX TABLE 51

MEAN AGES OF FROSTBITE CASES, EPIDEMIOLOGIC CONTROLS AND PRE-EXPOSURE CONTROLS BY RACE AND CLIMATIC REGION KOREA, 1951-52

Climatic Region	Cases				Epidemiologic Controls				Pre-Exposure Controls			
	White (405)		Negro (286)		White (404)		Negro (37)		White (1301)		Negro (277)	
	Mean Age	S.D.	Mean Age	S.D.	Mean Age	S.D.	Mean Age	S.D.	Mean Age	S.D.	Mean Age	S.D.
I	21.1	± 2.08	20.0	-	22.2	± 1.80	-	-	21.7	±3.77	21.0	-
II	22.2	± 2.14	22.4	± 2.97	22.8	± 2.14	22.0	-	21.6	± 2.34	22.1	±2.76
III	22.1	± 2.76	21.8	± 2.00	22.7	± 2.92	21.5	±1.59	21.7	± 2.49	21.4	±2.03
IV	21.9	± 3.25	21.1	± 2.14	21.7	± 2.08	21.4	±1.37	21.6	± 2.87	21.7	±2.17
V	22.5	± 1.80	22.8	± 2.27	23.8	± 3.44	22.5	±1.67	24.2	± 2.63	-	-
Total	22.0	± 2.69	21.6	± 2.20	22.5	± 2.53	21.9	±1.49	21.7	± 2.71	21.6	±2.14

RESTRICTED
Security Information

APPENDIX TABLE 52

DISTRIBUTION OF 407 WHITE CASES OF FROSTBITE ACCORDING TO RANK AND CLIMATIC REGION OF ORIGIN KOREA, 1951-52

Rank	Climatic Region											
	I		II		III		IV		V		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Private	6	28.6	24	26.1	40	26.1	24	22.2	16	48.5	110	27.0
Pfc	9	42.9	42	45.7	60	39.2	45	41.7	8	24.2	164	40.3
Cpl	1	4.8	17	18.5	28	18.3	23	21.3	4	12.1	73	17.9
Sgt	5	23.8	9	9.8	22	14.4	14	13.0	4	12.1	54	13.3
Co. Gd. Off.	0	-	0	-	3	2.0	2	1.9	1	3.0	6	1.5
Total	21	100.1	92	100.1	153	100.0	108	100.1	33	99.9	407	100.0

Chi square = 18.142 df = 16 P > .30 (By individual region)
Chi square = 3.748 df = 4 P > .30 (North vs South)

APPENDIX TABLE [illegible]

DISTRIBUTION OF 286 NEGRO CASES OF FROSTBITE ACCORDING TO RANK AND CLIMATIC REGION OF ORIGIN KOREA, 1951-52

Rank	Climatic Region											
	I		II		III		IV		V		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Pvt.	1	100.1	12	52.2	47	36.7	49	40.8	8	57.1	117	40.9
Pfc.	0	-	7	30.4	53	41.4	46	38.3	4	28.6	110	38.5
Cpl.	0	-	4	17.4	21	16.4	20	16.7	2	14.3	47	16.4
Sgt.	0	-	0	-	7	5.5	5	4.2	0	-	12	4.2
Co. Gd. Off.	0	-	0	-	0	-	0	-	0	-	0	-
Total	1	100.0	23	100.0	128	100.0	120	100.0	14	100.0	286	100.0

Chi square = 6.858 df = 12 P > .80 (By individual region)
Chi square = 2.808 df = 3 P > .30 (North vs South)

APPENDIX TABLE 54

DISTRIBUTION OF 404 WHITE BUNKER-MATE CONTROLS ACCORDING TO RANK AND CLIMATIC REGION OF ORIGIN KOREA, 1951-52

Rank	Climatic Region											
	I		II		III		IV		V		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Pvt	5	12.8	13	11.3	16	11.6	4	4.5	5	20.8	43	10.6
Pfc	12	30.8	41	35.7	44	31.9	40	45.5	11	45.8	148	36.6
Cpl	9	23.1	28	24.3	38	27.5	25	28.4	4	16.7	104	25.7
Sgt	13	33.3	33	28.7	38	27.5	18	20.5	4	16.7	106	26.2
Co. Gd. Off.	0	-	0	-	2	1.4	1	1.1	0	-	3	0.7
Total	39	100.0	115	100.0	138	99.9	88	100.0	24	100.0	404	99.8
Chi square = 16.324 df = 16 P > .30												

APPENDIX TABLE 55

DISTRIBUTION OF 37 NEGRO BUNKER-MATE CONTROLS ACCORDING TO RANK AND CLIMATIC REGION OF ORIGIN KOREA, 1951-52

Rank	Climatic Region											
	I		II		III		IV		V		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Pvt.	0	-	1	100.0	3	30.0	3	25.0	7	50.0	14	37.8
Pfc.	0	-	0	-	5	20.0	7	58.3	5	35.7	17	45.9
Cpl.	0	-	0	-	2	20.0	2	16.7	0	-	4	10.8
Sgt.	0	-	0	-	0	-	0	-	2	14.3	2	5.4
Co. Gd. Off.	0	-	0	-	0	-	0	-	0	-	0	-
Total	0	-	1	100.0	10	100.0	12	100.0	14	100.0	37	99.9

Chi square = 8.977 df = 9 P > .30

APPENDIX TABLE 56

COMPARISON OF CLIMATIC REGIONS OF ORIGIN WITH RESPECT TO DAYS SPENT IN KOREA BY 401 WHITE CASES OF FROSTBITE KOREA, 1951-52

Days in Korea	Climatic Region											
	I		II		III		IV		V		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
1 - 30	3	14.3	18	19.8	24	15.8	20	18.7	8	26.7	73	18.2
31 - 60	5	23.8	21	23.1	43	28.3	25	23.4	8	26.7	102	25.4
61 - 90	6	28.6	15	16.5	26	17.1	15	14.0	0	-	62	15.5
91 - 120	0	-	10	11.0	11	7.2	15	14.0	0	-	36	9.0
121 - 150	4	19.0	6	6.6	10	6.6	13	12.1	3	10.0	36	9.0
151 - 180	0	-	3	3.3	13	8.5	6	5.6	3	10.0	25	6.2
181 - 210	1	4.8	1	1.1	6	3.9	3	2.8	1	3.3	12	3.0
211 - 240	1	4.8	17	18.7	18	11.8	10	9.3	7	23.3	53	13.2
Over 240	1	4.8	0	-	1	0.6	0	-	0	-	2	0.5
Total	21	100.1	91	100.1	152	99.8	107	99.9	30	100.0	401	100.0

Chi square = 46.306 df = 32 P > .05 (By individual region)
Chi square = 6.749 df = 8 P > .50 (North vs South)

APPENDIX TABLE 57

COMPARISON OF CLIMATIC REGIONS OF ORIGIN WITH RESPECT TO DAYS SPENT IN KOREA BY 282 NEGRO CASES OF FROSTBITE KOREA, 1951-52

Days in Korea	Climatic Region											
	I		II		III		IV		V		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
1 - 30	0	-	5	22.7	11	8.7	14	11.9	2	14.3	32	11.3
31 - 60	1	100.0	1	4.5	19	15.0	9	7.6	5	35.7	35	12.4
61 - 90	0	-	6	27.3	16	12.6	20	16.9	2	14.3	44	15.6
91 - 120	0	-	3	13.6	16	12.6	21	17.8	0	-	40	14.2
121 - 150	0	-	2	9.1	19	15.0	14	11.9	0	-	35	12.4
151 - 180	0	-	2	9.1	10	7.9	8	6.8	0	-	20	77.1
181 - 210	0	-	0	-	7	5.5	5	4.2	1	7.1	13	4.6
211 - 240	0	-	3	13.6	29	22.8	25	21.2	4	28.6	61	21.6
Over 240	0	-	0	-	0	-	2	1.7	0	-	2	0.7
Total	1	100.0	22	99.9	127	100.1	118	100.0	14	100.0	282	99.9

Chi square = 38.195 df = 32 $P > .05$ (By individual region)
Chi square = 7.197 df = 8 $P > .50$ (North vs South)

RESTRICTED
Security Information

APPENDIX TABLE 58

COMPARISON OF CLIMATIC REGIONS OF ORIGIN WITH RESPECT TO DAYS SPENT IN KOREA BY 403 WHITE BUNKER-MATE CONTROLS KOREA, 1951-52

Days in Korea	Climatic Region											
	I		II		III		IV		V		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
1 - 30	5	12.8	28	24.3	20	14.6	24	27.3	3	12.5	80	19.8
31 - 60	4	10.3	20	17.4	31	22.6	14	15.9	2	8.3	71	17.6
61 - 90	6	15.4	25	21.7	20	14.6	14	15.9	0	-	65	16.1
91 - 120	8	20.5	9	7.8	15	10.9	8	9.1	2	8.3	42	10.4
121 - 150	5	12.8	0	-	3	2.2	3	3.4	1	4.2	12	2.9
151 - 180	2	5.1	13	11.3	11	8.0	7	7.9	3	12.5	36	8.9
181 - 210	2	5.1	7	6.1	12	8.8	12	13.6	2	8.3	35	8.7
211 - 240	2	5.1	3	2.6	12	8.8	2	2.3	11	45.8	30	7.4
Over 240	5	12.8	10	8.7	13	9.5	4	4.5	0	-	32	7.9
Total	39	99.9	115	99.9	137	100.0	88	99.9	24	99.9	403	99.7

Chi square = 103.996 $P < .001$

RESTRICTED
Security Information

APPENDIX TABLE 59

COMPARISON OF CLIMATIC REGIONS WITH RESPECT TO DAYS SPENT IN KOREA BY 37 NEGRO BUNKER-MATE CONTROLS KOREA, 1951-52

Days in Korea	Climatic Region											
	I		II		III		IV		V		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
1 - 30	0	-	1	100.0	0	-	1	8.3	1	7.1	3	8.1
31 - 60	0	-	0	-	1	10.0	0	-	2	14.3	3	8.1
61 - 90	0	-	0	-	1	10.0	3	25.0	5	35.7	9	24.3
91 - 120	0	-	0	-	3	30.0	0	-	0	-	3	8.1
121 - 150	0	-	0	-	1	10.0	3	25.0	1	7.1	5	13.5
151 - 180	0	-	0	-	0	-	2	16.6	2	14.2	4	10.8
181 - 210	0	-	0	-	1	10.0	1	8.3	0	-	2	5.4
211 - 240	0	-	0	-	2	20.0	2	16.6	3	21.4	7	18.9
Over 240	0	-	0	-	1	10.0	0	-	0	-	1	2.7
Total	0	-	1	100.0	10	100.0	12	99.8	14	99.8	37	99.9

Chi square = 28.734 P > .20

APPENDIX TABLE 60

COMPARISON OF MEAN DAYS SPENT IN COMBAT BY 668 CASES OF FROSTBITE AND 439 BUNKER-MATE CONTROLS ACCORDING TO REGION AND RACE
KOREA, 1951-52

Climatic Region	White						Negro					
	Cases			Controls			Cases			Controls		
	No.	Mean Days	S.D.	No.	Mean Days	S.D.	No.	Mean Days	S.D.	No.	Mean Days	S.D.
I	21	38.2	± 35.2	39	60.2	± 44.1	1	22.5	—	0	—	—
II	91	40.1	± 40.1	115	43.5	± 40.0	21	43.9	± 40.2	1	7.5	—
III	149	46.3	± 41.5	138	54.4	± 41.5	120	62.5	± 46.9	10	57.0	± 40.2
IV	105	46.4	± 40.0	86	49.4	± 43.7	117	64.7	± 45.8	12	67.5	± 43.8
V	29	58.2	± 55.3	24	78.1	± 55.8	14	58.9	± 56.2	14	39.6	± 29.2
Total	395	45.3	± 41.7	402	52.2	± 43.5	273	61.7	± 46.4	37	52.5	± 36.7

APPENDIX TABLE 61

COMPARISON OF MEAN DAYS SPENT IN COMBAT WITHOUT REST BY 654 CASES OF FROSTBITE AND 439 BUNKER-MATE CONTROLS ACCORDING TO REGION AND RACE
KOREA, 1951-52

Climatic Region	White						Negro					
	Cases			Controls			Cases			Controls		
	No.	Mean Days	S.D.	No.	Mean Days	S.D.	No.	Mean Days	S.D.	No.	Mean Days	S.D.
I	21	14.1	± 11.6	39	9.8	± 7.2	1	7.0	-	0	-	-
II	91	14.4	± 13.4	114	11.9	± 8.1	20	12.8	± 14.6	1	2.0	-
III	147	15.6	± 13.2	138	12.3	± 8.8	112	15.6	± 15.2	10	11.5	± 7.2
IV	103	16.6	± 13.7	83	11.8	± 9.0	116	17.4	± 15.9	12	9.1	± 5.7
V	30	16.7	± 15.1	24	8.9	± 7.0	13	15.5	± 16.4	13	10.1	± 7.2
TOTAL	392	15.6	± 13.5	403	11.6	± 8.5	262	16.1	± 15.4	36	9.9	± 6.3

RESTRICTED
Security Information

APPENDIX TABLE 62

COMPARISON OF CLIMATIC REGIONS WITH RESPECT TO HISTORY OF PREVIOUS COLD INJURY AMONG 383 WHITE CASES OF FROSTBITE
KOREA, 1951-52

Previous Cold Injury	Climatic Region											
	I		II		III		IV		V		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
None	11	55.0	67	75.3	111	76.0	87	85.3	24	92.3	300	78.3
Frostbite	9	45.0	21	23.6	33	22.6	15	14.7	2	7.7	80	20.9
Trenchfoot	0	-	0	-	1	0.7	0	-	0	-	1	0.3
Chilblains	0	-	1	1.1	1	0.7	0	-	-	-	2	0.5
TOTAL	20	100.0	89	100.0	146	100.0	102	100.0	26	100.0	383	100.0
Chi square = 4.139 df = 1 P <.05												

APPENDIX TABLE 63

COMPARISON OF CLIMATIC REGIONS OF ORIGIN WITH RESPECT TO HISTORY OF PREVIOUS COLD INJURY AMONG 270 NEGRO CASES WITH FROSTBITE
KOREA, 1951-52

Previous Cold Injury	Climatic Region											
	I		II		III		IV		V		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
None	1	100.0	17	85.0	91	74.6	104	91.2	12	92.3	225	83.3
Frostbite	0	-	3	15.0	31	25.4	10	8.8	1	7.7	45	16.7
Trenchfoot	0	-	0	-	0	-	0	-	0	-	0	-
Chilblains	0	-	0	-	0	-	0	-	0	-	0	-
TOTAL	1	100.0	20	100.0	122	100.0	114	100.0	13	100.0	270	100.0
Chi square = 0.093 df = 1 P >.70												

RESTRICTED
Security Information

RESTRICTED
Security Information

APPENDIX TABLE 64

COMPARISON OF CLIMATIC REGIONS OF ORIGIN WITH RESPECT TO HISTORY OF PREVIOUS COLD INJURY AMONG 397 WHITE BUNKER-MATE CONTROLS
KOREA, 1951-52

Previous Cold Injury	Climatic Region											
	I		II		III		IV		V		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
None	28	73.7	99	86.8	118	88.7	92	93.2	23	95.8	350	88.2
Frostbite	8	21.1	13	11.4	12	9.0	5	5.7	0	-	38	9.6
Trenchfoot	0	-	1	0.9	1	0.8	0	-	0	-	2	0.5
Chilblains	2	5.3	1	0.9	2	1.5	1	1.1	1	4.2	7	1.8
TOTAL	38	100.1	114	100.0	133	100.0	88	100.0	24	100.0	397	100.1

Chi square = 5.005 df = 1 P <.05

APPENDIX TABLE 65

COMPARISON OF CLIMATIC REGIONS OF ORIGIN WITH RESPECT TO HISTORY OF PREVIOUS COLD INJURY AMONG 36 NEGRO BUNKER-MATE CONTROLS
KOREA, 1951-52

Previous Cold Injury	Climatic Region											
	I		II		III		IV		V		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
None	0	-	1	100.0	10	100.0	11	100.0	11	78.6	33	91.7
Frostbite	0	-	0	-	0	-	0	-	0	-	0	-
Trenchfoot	0	-	0	-	0	-	0	-	0	-	0	-
Chilblains	0	-	0	-	0	-	0	-	3	21.4	3	8.3
TOTAL	0	-	1	100.0	10	100.0	11	100.0	14	100.0	36	100.0

Chi square = 0.115 df = 1 P >.70

RESTRICTED
Security Information

APPENDIX TABLE 66

COMPARISON OF CLIMATIC REGIONS OF ORIGIN WITH RESPECT TO HISTORY OF PREVIOUS COLD INJURY AMONG 1273 WHITE PRE-EXPOSURE CONTROLS
KOREA, 1951-52

Previous Cold Injury	Climatic Region											
	I		II		III		IV		V		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
None	90	66.2	304	86.6	474	90.5	226	93.4	15	75.0	1109	87.1
Frostbite	41	30.1	41	11.7	45	8.6	15	6.2	4	20.0	146	11.5
Trenchfoot	0	-	0	-	3	0.6	1	0.4	1	5.0	5	0.4
Chilblains	5	3.7	4	1.1	2	0.4	0	-	0	-	11	0.9
Frostbite & Trenchfoot	0	-	0	-	0	-	0	-	0	-	0	-
Frostbite & Chilblains	0	-	1	0.3	0	-	0	-	0	-	1	0.1
Trenchfoot & Chilblains	0	-	1	0.3	0	-	0	-	0	-	1	0.1
TOTAL	136	100.0	351	100.0	524	100.1	242	100.0	20	100.0	1273	100.1

APPENDIX TABLE 67

COMPARISON OF CLIMATIC REGIONS OF ORIGIN WITH RESPECT TO HISTORY OF PREVIOUS COLD INJURY AMONG 274 NEGRO PRE-EXPOSURE CONTROLS
KOREA, 1951-52

Previous Cold Injury	Climatic Region											
	I		II		III		IV		V		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
None	1	100.0	18	75.0	144	87.8	77	90.6	0	-	240	87.6
Frostbite	0	-	6	25.0	19	11.6	8	9.4	0	-	33	12.0
Trenchfoot	0	-	0	-	0	-	0	-	0	-	0	-
Chilblains	0	-	0	-	1	0.6	0	-	0	-	1	0.4
Frostbite & Trenchfoot	0	-	0	-	0	-	0	-	0	-	0	-
Frostbite & Chilblains	0	-	0	-	0	-	0	-	0	-	0	-
Trenchfoot & Chilblains	0	-	0	-	0	-	0	-	0	-	0	-
TOTAL	1	100.0	24	100.0	164	100.0	85	100.0	0	-	274	100.0

RESTRICTED
Security Information

APPENDIX TABLE 68

COMPARISON OF THE HISTORY OF PREVIOUS ILLNESSES AMONG 408 WHITE CASES OF FROSTBITE FROM THE SEVERAL CLIMATIC REGIONS KOREA, 1951-52

Previous Illnesses	Climatic Region											
	I		II		III		IV		V		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
None	17	81.0	81	88.0	125	81.7	76	70.4	26	76.5	325	79.7
Frequent Fevers	1	4.8	2	2.2	0	-	0	-	0	-	3	0.7
Pneumonia	2	9.5	7	7.5	21	13.7	25	23.1	3	8.8	58	14.2
Jaundice	0	-	0	-	0	-	0	-	0	-	0	-
Malaria	1	4.8	2	2.2	6	3.9	6	5.6	4	11.8	19	4.7
Raynauds	0	-	0	-	1	0.7	1	0.9	1	2.9	3	0.7
Hematuria	0	-	0	-	0	-	0	-	0	-	0	-
Syphilis	0	-	0	-	0	-	0	-	0	-	0	-
TOTAL	21	100.1	92	100.0	153	100.0	108	100.0	34	100.0	408	100.0

Chi square = 27.570 df = 16 $P < .05$

RESTRICTED
Security Information

RESTRICTED
Security Information

APPENDIX TABLE 69

COMPARISON OF THE HISTORY OF PREVIOUS ILLNESSES AMONG 286 NEGRO CASES OF FROSTBITE FROM THE SEVERAL CLIMATIC REGIONS
KOREA, 1951-52

Previous Illnesses	Climatic Region											
	I		II		III		IV		V		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
None	1	100.0	17	73.9	97	75.8	93	77.5	11	78.6	219	76.6
Frequent fevers	0	-	0	-	1	0.8	4	3.3	0	-	5	1.7
Pneumonia	0	-	4	17.4	20	15.6	11	9.2	0	-	35	12.2
Jaundice	0	-	0	-	0	-	1	0.8	0	-	1	0.3
Malaria	0	-	1	4.3	3	2.3	7	5.8	2	14.3	13	4.5
Raynauds	0	-	0	-	0	-	0	-	0	-	0	-
Hematuria	0	-	0	-	1	0.8	1	0.8	0	-	2	0.7
Syphilis	0	-	1	4.3	6	4.7	3	2.5	1	7.1	11	3.8
TOTAL	1	100.0	23	99.9	128	100.0	120	99.9	14	100.0	286	99.8

Chi square = 15.602 df = 24 P >.90

RESTRICTED
Security Information

APPENDIX TABLE 70

COMPARISON OF HISTORY OF PREVIOUS ILLNESSES AMONG 401 BUNKER-MATE CONTROLS FROM THE SEVERAL CLIMATIC REGIONS
KOREA, 1951-52

Previous Illnesses	Climatic Region											
	I		II		III		IV		V		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
None	33	84.6	81	71.1	109	76.8	60	64.5	1	7.7	284	70.8
Frequent fevers	0	-	1	0.9	1	0.7	1	1.1	0	-	3	0.7
Pneumonia	2	5.1	20	17.5	22	15.5	23	24.7	5	38.5	72	18.0
Jaundice	1	2.6	3	2.6	4	2.8	2	2.2	0	-	10	2.5
Malaria	1	2.6	6	5.3	3	2.1	5	5.4	6	46.2	21	5.2
Raynauds	1	2.6	0	-	0	-	0	-	0	-	1	0.2
Hematuria	0	-	2	1.8	3	2.1	2	2.2	1	7.7	8	2.0
Syphilis	1	2.6	1	0.9	0	-	0	-	0	-	2	0.5
TOTAL	39	100.1	114	100.1	142	100.0	93	100.1	13	100.1	401	99.9

Chi square = 79.685 df = 28 P <.001

RESTRICTED
Security Information

APPENDIX TABLE 71

COMPARISON OF HISTORY OF PREVIOUS ILLNESSES AMONG 30 NEGRO BUNKER-MATE CONTROLS FROM THE SEVERAL CLIMATIC REGIONS
KOREA, 1951-52

Previous Illnesses	Climatic Region											
	I		II		III		IV		V		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
None	0	-	1	100.0	6	60.0	9	64.3	1	20.0	17	56.7
Frequent fevers	0	-	0	-	0	-	1	7.1	0	-	1	3.3
Pneumonia	0	-	0	-	3	30.0	1	7.1	2	40.0	6	20.0
Jaundice	0	-	0	-	0	-	0	-	0	-	0	-
Malaria	0	-	0	-	0	-	1	7.1	2	40.0	3	10.0
[illegible]	0	-	0	-	0	-	0	-	0	-	0	-
Hematuria	0	-	0	-	1	10.0	1	7.1	0	-	2	6.7
Syphilis	0	-	0	-	0	-	1	7.1	0	-	1	3.3
TOTAL	0	-	1	100.0	10	100.0	14	99.8	5	100.0	30	100.0

Chi square = 12.676 df = 15 P >.50

RESTRICTED
Security Information

RESTRICTED
Security Information

APPENDIX TABLE 72

COMPARISON OF HISTORY OF PREVIOUS ILLNESSES AMONG 1083 WHITE PRE-EXPOSURE CONTROLS FROM THE SEVERAL CLIMATIC REGIONS KOREA, 1951-52

Previous Illnesses	Climatic Regions											
	I		II		III		IV		V		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
None	75	68.2	189	63.6	279	63.6	129	60.0	11	50.0	683	63.1
Frequent fevers	3	2.7	8	2.7	6	1.4	8	3.7	0	-	25	2.3
Pneumonia	22	20.0	68	22.9	109	24.8	51	23.7	4	18.2	254	23.5
Jaundice	8	7.3	13	4.4	16	3.6	2	0.9	1	4.5	40	3.7
Malaria	1	0.9	10	3.4	19	4.3	21	9.8	5	22.7	56	5.2
Raynauds	0	-	0	-	0	-	0	-	0	-	0	-
Hematuria	1	0.9	5	1.7	7	1.6	3	1.4	0	-	16	1.5
Syphilis	0	-	4	1.3	3	0.7	1	0.5	1	4.5	9	0.8
TOTAL	110	100.0	297	100.0	439	100.0	215	100.0	22	99.9	1083	100.1

Chi square = 50.559 df = 24 P <.01

RESTRICTED
Security Information

APPENDIX TABLE 73

COMPARISON OF HISTORY OF PREVIOUS ILLNESSES AMONG 264 NEGRO PRE-EXPOSURE CONTROLS FROM THE SEVERAL CLIMATIC REGIONS
KOREA, 1951-52

Previous Illnesses	Climatic Region											
	I		II		III		IV		V		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
None	0	-	17	65.4	105	69.1	49	57.0	0	-	171	64.8
Frequent fevers	0	-	0	-	0	-	6	7.0	0	-	6	2.3
Pneumonia	0	-	5	19.2	32	21.1	17	19.8	0	-	54	20.5
Jaundice	0	-	0	-	2	1.3	3	3.5	0	-	5	1.9
Malaria	0	-	3	11.5	4	2.6	6	7.0	0	-	13	4.9
[illegible]	0	-	0	-	0	-	0	-	0	-	0	-
Hematuria	0	-	0	-	1	0.7	1	1.2	0	-	2	0.8
Syphilis	0	-	1	3.8	8	5.3	4	4.7	0	-	13	4.9
TOTAL	0	-	26	99.9	152	100.1	86	100.2	0	-	264	100.1

Chi square = 20.505 df = 12 P >.05

RESTRICTED
Security Information

APPENDIX TABLE 74

COMPARISON OF AMOUNT OF SMOKING BY 400 WHITE CASES OF FROSTBITE FROM THE SEVERAL CLIMATIC REGIONS KOREA, 1951-52

Smoking	Climatic Region										Total	
	I		II		III		IV		V			
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
None	2	10.0	14	15.7	25	16.4	25	23.1	11	35.5	77	19.3
1/2 Pack daily	3	15.0	14	15.7	34	22.4	31	28.7	10	32.3	92	23.0
1 Pack daily	9	45.0	37	41.6	70	46.1	29	26.9	10	32.3	155	38.8
1 1/2 Pack daily	1	5.0	15	16.9	13	8.6	9	8.3	0	-	38	9.5
2 Packs daily	4	20.0	8	9.0	10	6.6	8	7.4	0	-	30	7.5
Over 2 packs daily	1	5.0	1	1.1	0	-	6	5.6	0	-	8	2.0
TOTAL	20	100.0	89	100.0	152	100.1	108	100.0	31	100.1	400	100.1
MEAN	1.1		1.0		0.8		0.8		0.5		0.9	
S.D.	± .70		± .59		± .63		± .70		± .41		± .61	

RESTRICTED
Security Information

APPENDIX TABLE 75

COMPARISON OF AMOUNT OF SMOKING BY 280 NEGRO CASES OF FROSTBITE FROM THE SEVERAL CLIMATIC REGIONS KOREA, 1951-52

Smoking	Climatic Region										Total	
	I		II		III		IV		V			
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
None	0	-	0	-	22	17.3	24	20.5	2	15.4	48	17.1
1/2 Pack daily	1	100.0	8	36.4	50	39.4	51	43.6	4	30.8	114	40.7
1 Pack daily	0	-	8	36.4	39	30.7	31	26.5	7	53.8	85	30.4
1 1/2 Pack daily	0	-	3	13.6	7	5.5	4	3.4	0	-	14	5.0
2 Packs daily	0	-	3	13.6	7	5.5	6	5.1	0	-	16	5.7
Over 2 packs daily	0	-	0	-	2	1.6	1	0.9	0	-	3	1.1
TOTAL	1	100.0	22	100.0	127	100.0	117	100.0	13	100.0	280	100.0
MEAN	0.5		1.0		0.7		0.7		0.7		0.7	
S.D.	-		± .54		± .55		± .53		± .40		± .54	

APPENDIX TABLE 76

COMPARISON OF AMOUNT OF SMOKING BY 393 WHITE BUNKER-MATZ CONTROLS FROM THE SEVERAL CLIMATIC REGIONS KOREA, 1951-52

Smoking	Climatic Region										Total	
	I		II		III		IV		V			
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
None	7	17.9	21	18.9	26	19.4	14	16.5	2	8.3	70	17.8
1/2 Pack daily	5	12.8	15	13.5	15	11.2	11	12.9	7	29.2	53	13.5
1 Pack daily	15	38.5	44	39.6	55	41.0	35	41.2	11	45.8	160	40.7
1 1/2 Pack daily	7	17.9	16	14.4	17	12.7	11	12.9	1	4.2	52	13.2
2 Packs daily	5	12.8	10	9.0	13	9.7	12	14.1	3	12.5	43	10.9
Over 2 packs daily	0	-	5	4.5	8	6.0	2	2.4	0	-	15	3.8
TOTAL	39	99.9	111	99.9	134	100.0	85	100.0	24	100.0	393	99.9
MEAN	1.0		1.0		1.0		1.0		0.9		1.0	
S.D.	± .62		± .64		± .70		± .65		± .56		± .66	

APPENDIX TABLE 77

COMPARISON OF THE AMOUNT OF SMOKING BY 35 NEGRO BUNKER-MATE CONTROLS
FROM THE SEVERAL CLIMATIC REGIONS
KOREA, 1951-52

Smoking	Climatic Region										Total	
	I		II		III		IV		V			
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
None	0	-	0	-	3	30.0	1	9.1	3	23.1	1	20.0
1/2 Pack daily	0	-	1	100.0	2	20.0	2	18.2	5	38.5	10	28.6
1 Pack daily	0	-	0	-	2	20.0	8	72.7	4	30.8	14	40.0
1 1/2 Pack daily	0	-	0	-	2	20.0	0	-	0	-	2	5.7
2 Packs daily	0	-	0	-	0	-	0	-	1	7.7	1	2.9
Over 2 packs daily	0	-	0	-	1	10.0	0	-	0	-	1	2.9
TOTAL	0	-	1	100.0	10	100.0	11	100.0	13	100.1	35	100.1
MEAN	-		0.5		0.9		0.8		0.7		0.8	
S.D.	-		-		± .86		± .35		± .58		± .57	

RESTRICTED
Security Information

APPENDIX TABLE 78

REGIONAL COMPARISONS OF MEAN INTERVAL IN HOURS SINCE LAST MEAL BEFORE FROSTBITE BY RACE FOR 665 CASES AND 440 BUNKER-MATE CONTROLS

Group	Climatic Region								
	I			II			III		
	No.	Mean Hours	S. D.	No.	Mean Hours	S. D.	No.	Mean Hours	S. D.
White case	21	8.5	± 5.44	89	6.9	± 4.69	148	8.6	± 5.60
White control	39	9.7	± 5.03	115	9.5	± 5.49	137	10.8	± 10.91
Negro case	1	4.0	-	21	6.1	± 3.77	121	9.6	± 7.47
Negro control	-	-	-	1	10.5	-	10	10.9	± 7.14

Group	Climatic Region						t*	P
	IV			V				
	No.	Mean Hours	S. D.	No.	Mean Hours	S. D.		
White case	105	8.9	± 5.05	29	9.0	± 6.40	2.72	<.01
White control	83	8.8	± 5.18	24	5.6	± 3.46	0.055	>.90
Negro case	116	9.8	± 7.18	14	8.5	± 5.53	3.869	<.001
Negro control	12	10.9	± 4.35	14	7.2	± 5.53	-	-

*In all instances "t" comparisons are between Northern regions (I and II) and Southern regions (III, IV and V).

RESTRICTED
Security Information

RESTRICTED
Security Information

APPENDIX TABLE 79

COMPARISON OF CLIMATIC REGIONS WITH RESPECT TO TYPE OF MEAL CONSUMED
JUST PRIOR TO FROSTBITE AMONG 401 WHITE CASES
KOREA, 1951-52

Type of Meal	Climatic Region										Total	
	I		II		III		IV		V			
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
C Ration	10	47.6	29	32.2	64	42.4	47	43.5	13	41.9	163	40.6
B Ration	9	42.9	55	61.1	81	53.6	58	53.7	15	48.4	218	54.4
Individual food packet	0	—	1	1.1	1	0.7	3	2.8	0	-	5	1.2
Native food	0	-	1	1.1	0	-	0	-	0	-	1	0.2
Less than C Ration or Individual food packet	2	9.5	4	4.4	5	3.3	0	-	3	9.7	14	3.5
TOTAL	21	100.0	90	99.9	151	100.0	108	100.0	31	100.0	401	99.9

Chi square = 20 920 df = 16 P >.10

RESTRICTED
Security Information

APPENDIX TABLE 80

COMPARISON OF CLIMATIC REGIONS WITH RESPECT TO TYPE OF MEAL CONSUMED BY 402 WHITE BUNKER-MATE CONTROLS JUST PRIOR TO BUNKER-MATE FROSTBITE
KOREA, 1951-52

Type of Meal	Climatic Region										Total	
	I		II		III		IV		V			
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
C Ration	22	56.4	59	51.8	58	42.0	40	46.0	5	20.8	184	45.8
B Ration	14	35.9	50	43.9	64	46.4	42	48.3	18	75.0	188	46.8
Individual food packet	0	-	0	-	0	-	0	-	0	-	0	-
Native food	0	-	0	-	0	-	0	-	0	-	0	-
Less than C Ration or Individual food packet	3	7.7	5	4.4	16	11.6	5	5.7	1	4.2	30	7.5
TOTAL	39	100.0	114	100.1	138	100.0	87	100.0	24	100.0	402	100.1

Chi square = 16.175 df = 8 P <.05 (By individual region)
Chi square = 5.728 df = 2 P >.05 (North vs South)

RESTRICTED
Security Information

APPENDIX TABLE 81

COMPARISON OF CLIMATIC REGIONS WITH RESPECT TO TYPE OF MEAL CONSUMED BY 37 NEGRO BUNKER-MATE CONTROLS JUST PRIOR TO BUNKER-MATE FROSTBITE
KOREA, 1951-52

Type of Meal	Climatic Region										Total	
	I		II		III		IV		V			
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
C Ration	0	-	1	100.0	5	50.0	6	50.0	4	28.6	16	43.2
B Ration	0	-	0	-	1	10.0	3	25.0	10	71.4	14	37.8
Individual food packet	0	-	0	-	0	-	0	-	0	-	0	-
Native food	0	-	0	-	0	-	0	-	0	-	0	-
Less than C Ration or Individual food packet	0	-	0	-	4	40.0	3	25.0	0	-	7	18.9
TOTAL	0	-	1	100.0	10	100.0	12	100.0	14	100.0	37	99.9

Chi square = 14.325 df = 8 P >.05

RESTRICTED
Security Information

RESTRICTED
Security Information

APPENDIX TABLE 82

COMPARISON OF CLIMATIC REGIONS WITH RESPECT TO TYPE OF MEAL CONSUMED JUST PRIOR TO FROSTBITE AMONG 282 NEGRO CASES KOREA, 1951-52

Type of Meal	Climatic Region										Total	
	I		II		III		IV		V			
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
C Ration	1	100.0	9	40.9	55	43.7	42	35.3	5	35.7	112	39.7
B Ration	0	-	12	54.5	68	54.0	71	59.7	9	64.3	160	56.7
Individual food packet	0	-	0	-	0	-	1	0.8	0	-	1	0.4
Native food	0	-	0	-	2	1.6	1	0.8	0	-	3	1.1
Less than C Ration or Individual food packet	0	-	1	4.5	1	0.8	4	3.4	0	-	6	2.1
TOTAL	1	100.0	22	99.9	126	100.1	119	100.0	14	100.0	282	100.0

Chi square = 7.791 df = 16 P >.95

RESTRICTED
Security Information

RESTRICTED
Security Information

APPENDIX TABLE 83

COMPARISON OF CLIMATIC REGIONS WITH RESPECT TO FOOTGEAR WORN BY 406 WHITE FROSTBITE CASES
KOREA, 1951-52

Footgear Worn	Climatic Region											
	I		II		III		IV		V		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Boots, service, combat, russet	4	19.0	11	12.1	24	15.7	15	13.9	10	30.3	64	15.8
Boots, service, combat, 2-buckle	4	19.0	25	27.5	23	15.0	19	17.6	13	39.4	84	20.7
Boots, leather, with overshoe	0	-	0	-	1	0.7	0	-	0	-	1	0.2
Shoepac	11	52.4	50	54.9	94	61.4	59	54.6	10	30.3	224	55.2
Boots, combat, rubber, insulated	2	9.5	4	4.4	10	6.5	13	12.0	0	-	29	7.1
Shoe, service	0	-	1	1.1	0	-	1	0.9	0	-	2	0.5
No footgear	0	-	0	-	1	0.7	1	0.9	0	-	2	0.5
Total	21	99.9	91	100.0	153	100.0	108	99.9	33	100.0	406	100.0

Chi square = 33.596 df = 24 P > .05

RESTRICTED
Security Information

APPENDIX TABLE 84

COMPARISON OF CLIMATIC REGIONS WITH RESPECT TO FOOTGEAR WORN BY 282 NEGRO FROSTBITE CASES
KOREA, 1951-52

Footgear Worn	Climatic Region											
	I		II		III		IV		V		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Boots, service, combat, russet	0	-	9	40.9	27	21.3	13	11.0	9	64.3	58	20.6
Boots, service, combat, 2-buckle	0	-	2	9.1	21	16.5	32	27.1	4	28.6	59	20.9
Boots, leather, with oversho	0	-	0	-	0	-	1	0.8	0	-	1	0.4
Shoepac	1	100.9	9	40.9	63	49.6	61	51.7	1	7.1	135	47.9
Boots, combat, rubber, insulated	0	-	2	9.1	15	11.8	9	7.6	0	-	26	9.2
Shoe, service	0	-	0	-	1	0.8	1	0.8	0	-	2	0.7
No footgear	0	-	0	-	0	-	1	0.8	0	-	1	0.4
Total	1	100.0	22	100.0	127	100.0	118	99.8	14	100.0	282	100.1

Chi square = 40.265 df = 24 P < .05 (By individual region)
Chi square = 6.443 df = 6 P > .30 (North vs South)

APPENDIX TABLE 85

COMPARISON OF CLIMATIC REGIONS WITH RESPECT TO FOOTGEAR WORN BY 404 WHITE BUNKER-MATE CONTROLS
KOREA, 1951-52

Footgear Worn	Climatic Region											
	I		II		III		IV		V		Total	
	No.	%	No.		No.	%	No.	%	No.	%	No.	%
Boots, service, combat, russet	11	28.2	22	19.1	28	20.3	19	21.6	12	50.0	92	22.8
Boots, service, combat, 2-buckle	3	7.7	14	12.2	20	14.5	5	5.7	8	33.3	50	12.4
Boots, leather, with overshoe	0	-	2	1.7	0	-	0	-	0	-	2	0.5
Shoepac	16	41.0	69	60.0	69	50.0	54	61.4	4	16.7	212	52.5
Boots, combat, rubber, insulated	9	23.1	8	7.0	21	15.2	10	11.4	0	-	48	11.9
Shoe, service	0	-	0	-	0	-	0	-	0	-	0	-
No footgear	0	-	0	-	0	-	0	-	0	-	0	-
Total	39	100.0	115	100.0	138	100.0	88	100.1	24	100.0	404	100.1

Chi square = 47.016 df = 16 P < .001 (By individual region)
Chi square = 4.282 df = 4 P > .30 (North vs South)

RESTRICTED
Security Information

APPENDIX TABLE 86

COMPARISON OF CLIMATIC REGIONS WITH RESPECT TO FOOTGEAR WORN BY 37 NEGRO BUNKER-MATE CONTROLS
KOREA, 1951-52

Footgear Worn	Climatic Region											
	I		II		III		IV		V		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Boots, service, combat, russet	0	-	0	-	1	10.0	1	8.3	8	57.1	10	27.0
Boots, service, combat, 2-buckle	0	-	0	-	5	50.0	2	16.7	6	42.9	13	35.1
Boots, lea'her, with overshoe	0	-	0	-	0	-	0	-	0	-	0	-
Shoepac	0	-	0	-	2	20.0	6	50.0	0	-	8	21.6
Boots, combat, rubber, insulated	0	-	1	100.0	2	20.0	3	25.0	0	-	6	16.2
Shoe, service	0	-	0	-	0	-	0	-	0	-	0	-
No footgear	0	-	0	-	0	-	0	-	0	-	0	-
Total	0	-	1	100.0	10	100.0	12	100.0	14	100.0	37	99.9

Chi square = 23.868 df = 9 P < .01 (By individual region)
Chi square = 5.312 df = 3 P > .10 (North vs South)

RESTRICTED
Security Information

APPENDIX TABLE 87

COMPARISON OF CLIMATIC REGIONS WITH RESPECT TO EXTRA FOOTWEAR CARRIED BY 396 WHITE FROSTBITE CASES
KOREA, 1951-52

Extra Footwear Carried	Climatic Region											
	I		II		III		IV		V		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Extra socks	11	52.4	25	27.8	40	27.0	32	30.2	14	45.2	122	30.8
Extra socks and insoles	5	23.8	28	31.1	55	37.2	39	36.8	6	19.4	133	33.6
No extra socks and no insoles	4	19.0	28	31.1	42	28.4	29	27.4	9	29.0	112	28.3
Extra insoles but no extra socks	0	-	3	3.3	1	0.7	2	1.9	0	-	6	1.5
Extra socks but no extra insoles	1	4.8	6	6.7	10	6.8	4	3.8	2	6.5	23	5.8
Total	21	100.0	90	100.0	148	100.0	106	100.1	31	100.1	396	100.0

Chi square = 15.153 df = 16 P > .50

APPENDIX TABLE 88

COMPARISON OF CLIMATIC REGIONS WITH RESPECT TO EXTRA FOOTWEAR CARRIED BY 403 WHITE BUNKER-MATE CONTROLS
KOREA, 1951-52

Extra Footwear Carried	Climatic Region											
	I		II		III		IV		V		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Extra socks	20	51.3	37	32.5	65	47.1	32	36.4	14	58.3	168	41.7
Extra socks and insoles	17	43.6	64	56.1	60	43.5	51	58.0	2	8.3	194	48.1
No extra socks and no insoles	2	5.1	11	9.6	8	5.8	4	4.5	6	25.0	31	7.7
Extra insoles but no extra socks	0	-	1	0.9	2	1.4	1	1.1	0	-	4	1.0
Extra socks but no extra insoles	0	-	1	0.9	3	2.2	0	-	2	8.3	6	1.5
Total	39	100.0	114	100.0	138	100.0	88	100.0	24	99.9	403	100.0

Chi square = 40.653 df = 16 $P < .001$ (By individual region)
Chi square = 3.990 df = 4 $P > .30$ (North vs South)

APPENDIX TABLE 89

COMPARISON OF CLIMATIC REGIONS WITH RESPECT TO EXTRA FOOTWEAR CARRIED BY 277 NEGRO FROSTBITE CASES
KOREA, 1951-52

Extra Footwear Carried	Climatic Region											
	I		II		III		IV		V		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Extra socks	0	-	8	40.0	37	29.4	39	33.1	5	41.7	89	32.1
Extra socks and insoles	1	100.0	5	25.0	41	32.5	34	28.8	0	-	81	29.2
No extra socks and no insoles	0	-	6	30.0	38	30.2	36	30.5	6	50.0	86	31.0
Extra insoles but no extra socks	0	-	0	-	2	1.6	1	0.8	0	-	3	1.1
Extra socks but no extra insoles	0	-	1	5.0	8	6.3	8	6.8	1	8.3	18	6.5
Total	1	100.0	20	100.0	126	100.0	118	100.0	12	100.0	277	99.9

Chi square = 9.714 df = 16 P > .80

APPENDIX TABLE 90

COMPARISON OF CLIMATIC REGIONS WITH RESPECT TO EXTRA FOOTWEAR CARRIED BY 37 NEGRO BUNKER-MATE CONTROLS
KOREA, 1951-52

Extra Footwear Carried	Climatic Region											
	I		II		III		IV		V		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Extra socks	0	-	1	100.0	8	80.0	6	50.0	9	64.3	24	64.9
Extra socks and insoles	0	-	0	-	2	20.0	5	41.7	0	-	7	18.9
No extra socks and no insoles	0	-	0	-	0	-	1	8.3	4	28.6	5	13.5
Extra insoles but no extra socks	0	-	0	-	0	-	0	-	0	-	0	-
Extra socks but no extra insoles	0	-	0	-	0	-	0	-	1	7.1	1	2.7
Total	0	-	1	100.0	10	100.0	12	100.0	14	100.0	37	100.0

Chi square = 12.780 df = 9 P > .10

RESTRICTED
Security Information

APPENDIX TABLE 91

COMPARISON OF CLIMATIC REGION WITH RESPECT AVERAGE CHANGE OF SOCKS AMONG 394 WHITE FROSTBITE CASES
KOREA, 1951-52

Average Change of Socks	Climatic Region											
	I		II		III		IV		V		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Every day	14	66.7	63	69.2	106	72.6	84	77.8	19	67.9	286	72.6
Every other day	4	19.0	21	23.1	22	15.1	15	13.9	3	10.7	65	16.5
Every third day	2	9.5	6	6.6	11	7.5	4	3.7	2	7.1	25	6.3
Every fourth day	1	4.8	0	-	4	2.7	1	0.9	1	3.6	7	1.8
Every fifth day	0	-	1	1.1	1	0.7	2	1.9	0	-	4	1.0
Every sixth day	0	-	0	-	2	1.4	2	1.9	3	10.7	7	1.8
Total	21	100.0	91	100.0	146	100.0	108	100.1	28	100.0	394	100.0

RESTRICTED
Security Information

APPENDIX TABLE 92

COMPARISON OF CLIMATIC REGION WITH RESPECT TO AVERAGE CHANGE OF SOCKS AMONG 396 WHITE BUNKER-MATE CONTROLS
KOREA, 1951-52

Average Change of Socks	Climatic Region											
	I		II		III		IV		V		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Every day	30	76.9	86	77.5	104	76.5	64	74.4	18	75.0	302	76.3
Every other day	5	12.8	18	16.2	21	15.4	15	17.4	2	8.3	61	15.4
Every third day	3	7.7	3	2.7	5	3.7	4	4.7	1	4.2	16	4.0
Every fourth day	0	-	1	0.9	3	2.2	2	2.3	2	8.3	8	2.0
Every fifth day	0	-	0	-	1	0.7	0	-	0	-	1	0.3
Every sixth day	1	2.6	3	2.7	2	1.5	1	1.2	1	4.2	8	2.0
Total	39	100.0	111	100.0	136	100.0	86	100.0	24	100.0	396	100.0

APPENDIX TABLE 93

COMPARISON OF CLIMATIC REGION WITH RESPECT TO AVERAGE CHANGE OF SOCKS AMONG 273 NEGRO FROSTBITE CASES
KOREA, 1951-52

Average Change of Socks	Climatic Region											
	I		II		III		IV		V		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Every day	0	-	14	63.6	76	63.3	67	57.3	4	30.8	161	59.0
Every other day	1	100.0	5	22.7	28	23.3	35	29.9	4	30.8	73	26.7
Every third day	0	-	2	9.1	8	6.7	10	8.5	2	15.4	22	8.1
Every fourth day	0	-	0	-	2	1.7	2	1.7	2	15.4	6	2.2
Every fifth day	0	-	0	-	0	-	1	0.9	0	-	1	0.4
Every sixth day	0	-	1	4.5	6	5.0	2	1.7	1	7.7	10	3.7
Total	1	100.0	22	99.9	120	100.0	117	100.0	13	100.1	273	100.1

APPENDIX TABLE 94

COMPARISON OF CLIMATIC REGION WITH RESPECT TO AVERAGE CHANGE OF SOCKS AMONG 37 NEGRO BUNKER-MATE CONTROLS
KOREA, 1951-52

Average Change of Socks	Climatic Region											
	I		II		III		IV		V		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Every day	0	-	0	-	5	50.0	10	83.3	8	57.1	23	62.2
Every other day	0	-	0	-	4	40.0	2	16.7	5	35.7	11	29.7
Every third day	0	-	1	100.0	1	10.0	0	-	1	7.1	3	8.1
Every fourth day	0	-	0	-	0	-	0	-	0	-	0	-
Every fifth day	0	-	0	-	0	-	0	-	0	-	0	-
Every sixth day	0	-	0	-	0	-	0	-	0	-	0	-
Total	0	-	1	100.0	10	100.0	12	100.0	14	99.9	37	100.0

APPENDIX TABLE 95

COMPARISON OF CLIMATIC REGION WITH RESPECT TO AVERAGE CHANGE OF INSOLES FOR 208 WHITE FROSTBITE CASES
KOREA, 1951-52

Average Change of Insoles	Climatic Region											
	I		II		III		IV		V		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Every day	8	72.7	35	71.4	72	85.7	43	75.4	6	85.7	164	78.8
Every other day	2	18.2	9	18.4	11	13.1	11	19.3	0	-	33	15.9
Every third day	1	9.1	3	6.1	1	1.2	2	3.5	0	-	7	3.4
Every fourth day	0	-	0	-	0	-	0	-	0	-	0	-
Every fifth day	0	-	0	-	0	-	0	-	0	-	0	-
Every sixth day	0	-	2	4.1	0	-	1	1.8	1	14.3	4	1.9
Total	11	100.0	49	100.0	84	100.0	57	100.0	7	100.0	208	100.0
Mean	1.36		1.51		1.15		1.35		1.71		1.32	
S. D.	± 0.7071		± 1.0903		± 0.3932		± 0.8055		± 2.0412		± 0.8187	

RESTRICTED
Security Information

RESTRICTED
Security Information

APPENDIX TABLE 96

COMPARISON OF CLIMATIC REGION WITH RESPECT TO AVERAGE CHANGE
OF INSOLES FOR 207 WHITE BUNKER-MATE CONTROLS
KOREA, 1951-52

Average Change of Insoles	Climatic Region											
	I		II		III		IV		V		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Every day	13	76.5	53	77.9	49	74.2	44	83.0	3	100.0	162	78.3
Every other day	4	23.5	12	17.6	10	15.2	6	11.3	0	-	32	15.5
Every third day	0	-	2	2.9	3	4.5	1	1.9	0	-	6	2.9
Every fourth day	0	-	1	1.5	0	-	1	1.9	0	-	2	1.0
Every fifth day	0	-	0	-	0	-	0	-	0	-	0	-
Every sixth day	0	-	0	-	4	6.1	1	1.9	0	-	5	2.4
TOTAL	17	100.0	68	99.9	66	100.0	53	100.0	3	100.0	207	100.1
MEAN	1.23		1.28		1.55		1.30		1.00		1.36	
S.D.	± 0.4507		± 0.5903		± 1.2454		± 0.8598		-		± 0.9111	

RESTRICTED
Security Information

APPENDIX TABLE 97

COMPARISON OF CLIMATIC REGION WITH RESPECT TO AVERAGE CHANGE OF
INSOLES FOR 9 NEGRO BUNKER-MATE CONTROLS
KOREA, 1951-52

Average Change of Insoles	Climatic Region											
	I		II		III		IV		V		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Every day	0	-	0	-	2	66.7	4	66.7	0	-	6	66.7
Every other day	0	-	0	-	1	33.3	1	16.7	0	-	2	22.2
Every third day	0	-	0	-	0	-	1	16.7	0	-	1	11.1
Every fourth day	0	-	0	-	0	-	0	-	0	-	0	-
Every fifth day	0	-	0	-	0	-	0	-	0	-	0	-
Every sixth day	0	-	0	-	0	-	0	-	0	-	0	-
TOTAL	0	-	0	-	3	100.0	6	100.1	0	-	9	100.0
MEAN	-		-		1.33		1.50		-		1.44	
S.D.	-		-		± 0.71		± 0.92		-		± 0.73	

RESTRICTED
Security Information

RESTRICTED
Security Information

APPENDIX TABLE 98

COMPARISON OF CLIMATIC REGION WITH RESPECT TO AVERAGE CHANGE OF INSOLES FOR 118 NEGRO FROSTBITE CASES
KOREA, 1951-52

Average Change of Insoles	Climatic Region											
	I		II		III		IV		V		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Every day	0	-	7	77.8	33	73.1	38	69.1	0	-	83	70.3
Every other day	1	100.0	1	11.1	9	17.3	13	23.6	1	100.0	25	21.2
Every third day	0	-	1	11.1	2	3.8	3	5.5	0	-	6	5.1
Every fourth day	0	-	0	-	0	-	0	-	0	-	0	-
Every fifth day	0	-	0	-	0	-	0	-	0	-	0	-
Every sixth day	0	-	0	-	3	5.8	1	1.8	0	-	4	3.4
TOTAL	1	100.0	9	100.0	52	100.0	55	100.0	1	100.0	118	100.0
MEAN	2.00		1.33		1.54		1.44		2.00		1.48	
S.D.	-		± 0.75		± 1.22		± 0.85		-		± 1.01	

RESTRICTED
Security Information

RESTRICTED
Security Information

APPENDIX TABLE 99

COMPARISON OF CLIMATIC REGION WITH RESPECT TO SOCKGEAR
WORN BY 404 WHITE FROSTBITE CASES
KOREA, 1951-52

Sockgear Worn	Climatic Region											
	I		II		III		IV		V		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Socks, wool, cushion sole 1 pair	4	19.0	29	32.2	44	28.8	34	31.5	11	34.4	122	30.2
Socks, wool, cushion sole 2 pair	3	14.3	4	4.4	3	2.0	4	3.7	9	28.1	23	5.7
Socks, wool, ski 1 pair	2	9.5	13	14.4	16	10.5	12	11.1	2	6.3	45	11.1
Socks, wool, ski 2 pair	8	38.1	31	34.4	60	39.2	32	29.6	8	25.0	139	34.4
Socks, wool, ski 3 pair	0	-	0	—	0	-	1	0.9	0	-	1	0.2
Socks, wool, cushion sole and Socks, wool ski	4	19.0	13	14.4	28	18.3	24	22.2	2	6.3	71	17.6
No socks	0	-	0	-	2	1.3	1	0.9	0	-	3	0.7
Combinations other than item six	0	-	0	-	0	-	0	-	0	-	0	-
TOTAL	21	99.9	90	99.8	153	100.1	108	99.9	32	100.1	404	99.9

Chi square = 50.450 df = 24 P <.01 (By individual region)
Chi square = 2.839 df = 6 P >.80 (North vs South)

RESTRICTED
Security Information

APPENDIX TABLE 100

COMPARISON OF CLIMATIC REGIONS WITH RESPECT TO SOCKGEAR WORN
BY 404 WHITE BUNKER-MATE CONTROLS
KOREA, 1951-52

Sockgear Worn	Climatic Region											
	I		II		III		IV		V		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Socks, wool, cushion sole 1 pair	18	46.2	36	31.3	53	38.4	27	30.7	14	58.3	148	36.6
Socks, wool, cushion sole 2 pair	1	2.6	8	7.0	7	5.1	5	5.7	1	4.2	22	5.4
Socks, wool, ski 1 pair	2	5.1	4	3.5	3	2.2	2	2.3	1	4.2	12	3.0
Socks, wool, ski 2 pair	3	7.7	34	29.6	34	24.6	31	35.2	7	29.2	109	27.0
Socks, wool, ski 3 pair	1	2.5	2	1.7	1	0.7	1	1.1	0	-	5	1.2
Socks, wool, cushion sole and Socks, wool ski	8	20.5	18	15.7	22	15.9	11	12.5	1	4.2	60	14.9
No socks	0	-	0	-	0	-	0	-	0	-	0	-
Combinations other than item six	6	15.4	13	11.3	18	13.0	11	12.5	0	-	48	11.9
TOTAL	39	100.0	115	100.1	138	99.9	88	100.0	24	100.1	404	100.0

Chi square = 24.427 df = 24 P >.30

APPENDIX TABLE 101

COMPARISON OF CLIMATIC REGION WITH RESPECT TO SOCKGEAR WORN BY 281 NEGRO FROSTBITE CASES KOREA, 1951-52

Sockgear Worn	Climatic Region											
	I		II		III		IV		V		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Socks, wool, cushion sole 1 pair	0	-	10	45.5	55	43.7	38	32.2	6	42.9	109	38.8
Socks, wool, cushion sole 2 pair	0	-	3	13.6	6	4.8	9	7.6	3	21.4	21	7.4
Socks, wool, ski 1 pair	0	—	1	4.5	12	9.5	13	11.0	1	7.1	27	9.6
Socks, wool, ski 2 pair	0	-	4	18.2	23	18.3	27	22.9	1	7.1	55	19.6
Socks, wool, ski 3 pair	0	-	1	4.5	0	-	1	0.8	0	-	2	0.7
Socks, wool, cushion sole and Socks, wool ski	1	100.0	3	13.6	30	23.8	28	23.7	3	21.4	65	23.1
No socks	0	-	0	-	0	-	2	1.7	0	-	2	0.7
Combinations other than item six	0	-	0	-	0	-	0	-	0	-	0	-
TOTAL	1	100.0	22	99.9	126	100.1	118	99.9	14	99.9	281	99.9

Chi square = 23.822 df = 24 P >.30

APPENDIX TABLE 102

COMPARISON OF CLIMATIC REGION WITH RESPECT TO SOCKGEAR
WORN BY 37 NEGRO BUNKER-MATE CONTROLS
KOREA, 1951-52

Sockgear Worn	Climatic Region											
	I		II		III		IV		V		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Socks, wool, cushion sole 1 pair	0	-	1	100.0	6	60.0	5	41.7	10	71.4	22	59.5
Socks, wool, cushion sole 2 pair	0	-	0	-	1	10.0	0	-	3	21.4	4	10.8
Socks, wool, ski 1 pair	0	-	0	-	1	10.0	1	8.3	0	-	2	5.4
Socks, wool, ski 2 pair	0	-	0	-	1	10.0	3	25.0	0	-	4	10.8
Socks, wool, ski 3 pair	0	-	0	-	0	-	0	-	0	-	0	-
Socks, wool, cushion sole and Socks, wool ski	0	-	0	-	0	-	2	16.7	1	7.1	3	8.1
No socks	0	-	0	-	0	-	0	-	0	-	0	-
Combinations other than item six	0	-	0	-	1	10.0	1	8.3	0	-	2	5.4
TOTAL	0	-	1	100.0	10	100.0	12	100.0	14	99.9	37	100.0

Chi square = 13.122 df = 15 P >.50

APPENDIX TABLE 103

COMPARISON OF CLIMATIC REGIONS WITH RESPECT TO INTERVAL IN DAYS BETWEEN LAST CHANGE OF SOCKS AND ONSET OF FROSTBITE AMONG 398 WHITE CASES
KOREA, 1951-52

Last Change of Socks	Climatic Region											
	I		II		III		IV		V		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Less than one day	13	61.9	60	67.4	108	71.5	68	63.0	17	58.6	266	66.8
1 - 2 days	6	28.6	22	24.7	28	18.5	35	32.4	6	20.7	97	24.4
2 - 3 days	1	4.8	4	4.5	7	4.6	1	0.9	0	-	13	3.3
3 - 4 days	1	4.8	3	3.4	2	1.3	4	3.7	2	6.9	12	3.0
4 - 5 days	0	-	0	-	0	-	0	-	0	-	0	-
Over 5 days	0	-	0	-	6	4.0	0	-	4	13.8	10	2.5
Total	21	100.1	89	100.0	151	99.9	108	100.0	29	100.0	398	100.0

Chi square = 36.057 df = 16 P < .01 (By individual region)
Chi square = 4.926 df = 4 P > .20 (North vs South)

APPENDIX TABLE 104

RESTRICTED
Security Information

COMPARISON OF CLIMATIC REGION WITH RESPECT TO INTERVAL IN DAYS BETWEEN LAST CHANGE OF SOCKS AND ONSET OF FROSTBITE AMONG 402 WHITE BUNKER-MATE CONTROLS KOREA, 1951-52

Last Change of Socks	Climatic Region											
	I		II		III		IV		V		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Less than one day	22	56.4	59	51.8	81	58.7	54	62.1	18	75.0	234	58.2
1-2 days	12	30.8	44	38.6	44	31.9	21	24.1	3	12.5	124	30.8
2-3 days	2	5.1	6	5.3	10	7.2	10	11.5	2	8.3	30	7.5
3-4 days	2	5.1	2	1.8	2	1.4	1	1.1	1	4.2	8	2.0
4-5 days	0	-	0	-	1	0.7	0	-	0	-	1	0.2
Over 5 days	1	2.6	3	2.6	0	-	1	1.1	0	-	5	1.2
TOTAL	39	100.0	114	100.1	138	99.9	87	99.9	24	100.0	402	99.9

Chi square = 20.751 df = 20 P >.30

APPENDIX TABLE 105

COMPARISON OF CLIMATIC REGION WITH RESPECT TO INTERVAL IN DAYS, BETWEEN LAST CHANGE OF SOCKS AND ONSET OF FROSTBITE AMONG 283 NEGRO FROSTBITE CASES KOREA, 1951-52

Last Change of Socks	Climatic Region											
	I		II		III		IV		V		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Less than one day	1	100.0	15	68.2	77	60.6	77	64.7	4	28.6	174	61.5
1-2 days	0	-	4	18.2	30	23.6	29	24.4	6	42.9	69	24.4
2-3 days	0	-	1	4.5	7	5.5	9	7.6	1	7.1	18	6.4
3-4 days	0	-	1	4.5	3	2.4	1	0.8	1	7.1	6	2.1
4-5 days	0	-	0	-	2	1.6	0	-	0	-	2	0.7
Over 5 days	0	-	1	4.5	8	6.3	3	2.5	2	14.3	14	4.9
TOTAL	1	100.0	22	99.9	127	100.0	119	100.0	14	100.0	283	100.0

Chi square = 16.141 df = 20 P >.70

RESTRICTED
Security Information

APPENDIX TABLE 106

COMPARISON OF CLIMATIC REGIONS WITH RESPECT TO INTERVAL IN DAYS, BETWEEN LAST CHANGE OF SOCKS AND ONSET OF FROSTBITE AMONG 37 NEGRO BUNKER-MATE CONTROLS
KOREA, 1951-52

Last Change of Socks	Climatic Region											
	I		II		III		IV		V		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Less than one day	0	-	0	-	3	30.0	7	58.3	8	57.1	18	48.6
1-2 days	0	-	1	100.0	5	50.0	3	25.0	6	42.9	15	40.5
2-3 days	0	-	0	-	1	10.0	2	16.7	0	-	3	8.1
3-4 days	0	-	0	-	1	10.0	0	-	0	-	1	2.7
4-5 days	0	-	0	-	0	-	0	-	0	-	0	-
Over 5 days	0	-	0	-	0	-	0	-	0	-	0	-
TOTAL	0	-	1	100.0	10	100.0	12	100.0	14	100.0	37	99.9

Chi square = 8.130 df = 9 P >.50

APPENDIX TABLE 107

COMPARISON OF CLIMATIC REGIONS WITH RESPECT TO CONDITION OF THE FEET AT TIME OF FROSTBITE AMONG 398 WHITE CASES
KOREA, 1951-52

Condition of Feet	Climatic Region											
	I		II		III		IV		V		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Dry	3	14.3	28	31.5	34	22.7	32	29.6	14	46.7	111	27.9
Wet with sweat	9	42.9	38	42.7	81	54.0	46	42.6	6	20.0	180	45.2
Wet from muddy ground	1	4.8	0	-	4	2.7	2	1.9	0	-	7	1.8
Wet from melted snow	6	28.6	18	20.2	27	18.0	22	20.4	9	30.0	82	20.6
Wet from wading in water	2	9.5	5	5.6	4	2.7	6	5.6	1	3.3	18	4.5
TOTAL	21	100.1	89	100.0	150	100.1	108	100.1	30	100.0	398	100.0

Chi square = 23.588 df = 16 P >.05

RESTRICTED
Security Information

APPENDIX TABLE 108

COMPARISON OF CLIMATIC REGIONS WITH RESPECT TO CONDITION OF THE FEET AT TIME OF FROSTBITE AMONG 402 WHITE BUNKER-MATE CONTROLS KOREA, 1951-52

Condition of Feet	Climatic Region											
	I		II		III		IV		V		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Dry	10	25.6	30	26.1	31	22.6	15	17.2	12	50.0	98	24.4
Wet with sweat	18	46.2	63	54.8	70	51.1	54	62.1	10	41.7	215	53.5
Wet from muddy ground	0	-	0	-	0	-	0	-	1	4.2	1	0.2
Wet from melted snow	11	28.2	21	18.3	33	24.1	17	19.5	1	4.2	83	20.6
Wet from wading in water	0	-	1	0.9	3	2.2	1	1.1	0	—	5	1.2
TOTAL	39	100.0	115	100.1	137	100.0	87	99.9	24	100.0	402	99.9

Chi square = 27.171 df = 16 P <.05 (By individual region)
Chi square = 1.605 df = 4 P >.80 (North vs South)

RESTRICTED
Security Information

APPENDIX TABLE 109

COMPARISON OF CLIMATIC REGIONS WITH RESPECT TO CONDITION OF THE FEET
AT TIME OF FROSTBITE AMONG 280 NEGRO FROSTBITE CASES
KOREA, 1951-52

Condition of Feet	Climatic Region											
	I		II		III		IV		V		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Dry	0	-	8	36.4	46	36.5	44	37.3	6	46.2	104	37.1
Wet with sweat	1	100.0	10	45.5	50	39.7	42	35.6	2	15.4	105	37.5
Wet from muddy ground	0	-	0	-	0	-	4	3.4	0	-	4	1.4
Wet from melted snow	0	-	4	18.2	26	20.6	24	20.3	5	38.4	59	21.1
Wet from wading in water	0	-	0	-	4	3.2	4	3.3	0	-	8	2.9
TOTAL	1	100.0	22	100.1	126	100.0	118	99.9	13	100.0	280	100.0

Chi square = 12.803 df = 16 P >.50

APPENDIX TABLE 110

COMPARISON OF CLIMATIC REGIONS WITH RESPECT TO CONDITION OF THE FEET AT TIME OF FROSTBITE AMONG 37 NEGRO BUNKER-MATE CONTROLS
KOREA, 1951-52

Condition of Feet	Climatic Region											
	I		II		III		IV		V		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Dry	0	-	0	-	1	10.0	2	16.7	8	57.1	11	29.7
Wet with sweat	0	-	1	100.0	5	50.0	8	66.7	5	35.7	19	51.4
Wet from muddy ground	0	-	0	-	0	-	0	-	0	-	0	-
Wet from melted snow	0	-	0	-	4	40.0	2	16.7	1	7.1	7	18.9
Wet from wading in water	0	-	0	-	0	-	0	-	0	-	0	-
TOTAL	-	-	1	100.0	10	100.0	12	100.1	14	99.9	37	100.0

Chi square = 11.024 df = 6 P >.05

RESTRICTED
Security Information

APPENDIX TABLE 111

COMPARISON OF CLIMATIC REGIONS WITH RESPECT TO CONDITIONS OF HANDS AMONG 397 WHITE FROSTBITE CASES
KOREA, 1951-52

Condition of Hands	Climatic Region											
	I		II		III		IV		V		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Dry	13	65.0	70	79.5	119	79.3	76	70.4	28	90.3	306	77.1
Wet from sweat	5	25.0	6	6.8	13	8.7	7	6.5	1	3.2	32	8.1
Wet from water	2	10.0	12	13.6	18	12.0	21	19.4	1	3.2	54	13.6
Wet from other liquids	0	-	0	-	0	-	4	3.7	1	3.2	5	1.3
TOTAL	20	100.0	88	99.9	150	100.0	108	100.0	31	99.9	397	100.1

Chi square = 25.197 df = 12 P <.02 (By individual region)
Chi square = 2.826 df = 3 P >.30 (North vs South)

APPENDIX TABLE 112

COMPARISON OF CLIMATIC REGIONS WITH RESPECT TO CONDITION OF HANDS AMONG 400 WHITE BUNKER-MATE CONTROLS
KOREA, 1951-52

Condition of Feet	Climatic Region											
	I		II		III		IV		V		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Dry	29	76.3	87	76.3	118	86.1	69	79.3	23	95.8	326	81.5
Wet from sweat	6	15.8	18	15.8	10	7.3	12	13.8	1	4.2	47	11.8
Wet from water	3	7.9	9	7.9	9	6.6	6	6.9	0	-	27	6.8
Wet from other liquids	0	-	0	-	0	-	0	-	0	-	0	-
TOTAL	38	100.0	114	100.0	137	100.0	87	100.0	24	100.0	400	100.1

Chi square = 9.252 df = 8 P >.30

RESTRICTED
Security Information

RESTRICTED
Security Information

APPENDIX TABLE 113

COMPARISON OF CLIMATIC REGIONS WITH RESPECT TO CONDITION OF HANDS AMONG 278 NEGRO FROSTBITE CASES
KOREA, 1951-52

Condition of Hands	Climatic Region											
	I		II		III		IV		V		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Dry	1	100.0	19	86.4	97	78.2	95	80.5	10	76.9	222	79.9
Wet from sweat	0	-	0	-	11	9.0	0	7.6	1	7.7	21	7.6
Wet from water	0	-	3	13.6	16	12.9	13	11.0	2	15.4	34	12.2
Wet from other liquids	0	-	0	-	0	-	1	0.8	0	-	1	0.4
TOTAL	1	100.0	22	100.0	124	100.0	118	99.9	13	100.0	278	100.1

Chi square = 4.209 df = 12 P >.95

APPENDIX TABLE 114

COMPARISON OF CLIMATIC REGIONS WITH RESPECT TO CONDITION OF HANDS AMONG 36 NEGRO BUNKER-MATE CONTROLS
KOREA, 1951-52

Condition of Hands	Climatic Region											
	I		II		III		IV		V		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Dry	0	-	1	100.0	9	90.0	11	100.0	14	100.0	35	97.2
Wet from sweat	0	-	0	-	1	10.0	0	-	0	-	1	2.8
Wet from water	0	-	0	-	0	-	0	-	0	-	0	-
Wet from other liquids	0	-	0	-	0	-	0	-	0	-	0	-
TOTAL	0	-	1	100.0	10	100.0	11	100.0	14	100.0	36	100.0

Chi square = 2.353 df = 4 P >.50

RESTRICTED
Security Information

APPENDIX TABLE 115

COMPARISON OF CLIMATIC REGIONS WITH RESPECT TO TYPE AND DEGREE OF ACTIVITY AMONG 402 WHITE FROSTBITE CASES
KOREA, 1951-52

Activity at time of Exposure	Climatic Region											
	I		II		III		IV		V		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Sleeping	2	9.5	2	2.2	3	2.0	4	3.7	1	3.2	12	3.0
Lying, kneeling, or sitting with no movement	3	14.3	10	11.1	15	9.8	12	11.1	1	3.2	41	10.2
Lying, kneeling, or sitting with little movement	8	38.1	31	34.4	41	27.0	32	29.6	4	12.9	116	28.9
Lying, kneeling, or sitting with considerable movement	0	-	1	1.1	3	2.0	2	1.9	1	3.2	7	1.7
Standing with no movement	1	4.8	0	-	6	3.9	0	-	2	6.5	9	2.2
Standing with little movement	5	23.8	21	23.3	55	36.2	30	27.8	6	19.4	117	29.1
Standing with considerable movement	1	4.8	7	7.8	6	3.9	2	1.9	3	9.7	19	4.7
Walking with infrequent breaks	0	-	3	3.3	8	5.3	11	10.2	8	25.8	30	7.5
Walking with frequent breaks	1	4.8	15	16.7	15	9.9	15	13.9	5	16.1	51	12.7
TOTAL	21	100.1	90	99.9	152	100.0	108	100.1	31	100.0	402	100.0

Chi square = 54.773 df = 32 P = .006 (By individual region)
Chi square = 13.310 df = 8 P >.10 (North vs South)

RESTRICTED
Security Information

APPENDIX TABLE 116

COMPARISON OF CLIMATIC REGIONS WITH RESPECT TO TYPE AND DEGREE OF ACTIVITY AMONG 284 NEGRO FROSTBITE CASES
KOREA, 1951-52

Activity at time of Exposure	Climatic Region											
	I		II		III		IV		V		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Sleeping	0	-	1	4.3	8	6.3	7	5.9	1	7.1	17	6.0
Lying, kneeling, or sitting with no movement	1	100.0	5	21.7	7	5.5	13	10.9	1	7.1	27	9.5
Lying, kneeling, or sitting with little movement	0	-	7	30.4	39	30.7	30	25.2	0	-	76	26.8
Lying, kneeling, or sitting with considerable movement	0	-	0	-	1	0.8	7	5.9	1	7.1	9	3.2
Standing with no movement	0	-	1	4.3	4	3.1	3	2.5	2	14.3	10	3.5
Standing with little movement	0	-	5	21.7	35	27.6	32	26.9	7	50.0	79	27.8
Standing with considerable movement	0	-	0	-	9	7.1	9	7.6	0	-	18	6.3
Walking with infrequent breaks	0	-	1	4.3	11	8.7	10	8.4	2	14.3	24	8.5
Walking with frequent breaks	0	-	3	13.0	13	10.2	8	6.7	0	-	24	8.5
TOTAL	1	100.0	23	99.7	127	100.0	119	100.0	14	99.9	284	100.1

Chi square = 40.830 df = 32 P >.10

APPENDIX TABLE 117

COMPARISON OF CLIMATIC REGIONS WITH RESPECT TO TYPE AND DEGREE OF ACTIVITY AMONG 404 WHITE BUNKER-MATE CONTROLS KOREA, 1951-52

Activity at time of Exposure	Climatic Regions											
	I		II		III		IV		V		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Sleeping	0	-	1	0.9	0	-	0	-	0	-	1	0.2
Lying, kneeling, or sitting with no movement	10	25.6	9	7.8	18	13.0	8	9.1	3	12.5	48	11.9
Lying, kneeling, or sitting with little movement	12	30.8	41	35.7	46	33.3	28	31.8	2	8.3	129	31.9
Lying, kneeling, or sitting with considerable movement	4	10.3	19	16.5	21	15.2	15	17.0	1	4.2	60	14.9
Standing with no movement	0	-	0	-	2	1.4	0	-	7	29.2	9	2.2
Standing with little movement	3	7.7	13	11.3	10	7.2	8	9.1	3	12.5	37	9.2
Standing with considerable movement	6	15.4	16	13.9	23	16.7	13	14.8	0	-	58	14.4
Walking with infrequent breaks	2	5.1	4	3.5	7	5.1	10	11.4	2	8.3	25	6.2
Walking with frequent breaks	2	5.1	12	10.4	11	8.0	6	6.8	6	25.0	37	9.2
TOTAL	39	100.0	115	100.0	138	99.9	88	100.0	24	100.0	404	100.1

Chi square = 128.695 df = 32 P <.001 (By individual region)
Chi square = 9.978 df = 8 P >.20 (North vs South)

APPENDIX TABLE 118

COMPARISON OF CLIMATIC REGIONS WITH RESPECT TO TYPE AND DEGREE OF ACTIVITY AMONG 37 NEGRO BUNKER-MATE CONTROLS
KOREA, 1951-52

Activity at time of Exposure	Climatic Regions											
	I		II		III		IV		V		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Sleeping	0	-	0	-	0	-	0	-	0	-	0	-
Lying, kneeling, or sitting with no movement	0	-	0	-	1	10.0	1	8.3	0	-	2	5.4
Lying, kneeling, or sitting with little movement	0	-	0	-	4	40.0	2	16.7	0	-	6	16.2
Lying, kneeling, or sitting with considerable movement	0	-	0	-	5	50.0	4	33.3	0	-	9	24.3
Standing with no movement	0	-	0	-	0	-	0	-	3	21.4	3	8.1
Standing with little movement	0	-	1	100.0	0	-	1	8.3	6	42.9	8	21.6
Standing with considerable movement	0	-	0	-	0	-	2	16.7	1	7.1	3	8.1
Walking with infrequent breaks	0	-	0	-	0	-	1	8.3	3	21.4	4	10.8
Walking with frequent breaks	0	-	0	-	0	-	1	8.3	1	7.1	2	5.4
TOTAL	0	-	1	100.0	10	100.0	12	99.9	14	99.9	37	99.9

Chi square = 34.767 df = 21 P <.05 (By individual region)
Chi square = 4.214 df = 7 P >.70 (North vs South)

RESTRICTED
Security Information

APPENDIX TABLE 119

COMPARISON OF CLIMATIC REGIONS WITH RESPECT TO MINIMUM TEMPERATURE OF EXPOSURE AMONG 370 WHITE FROSTBITE CASES
KOREA, 1951-52

(°F) Minimum Temperature of Exposure	Climatic Region											
	I		II		III		IV		V		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
More than 37	0	-	0	-	2	1.4	0	-	2	7.1	4	1.1
31 to 37	0	-	0	-	5	3.4	3	3.1	2	7.1	10	2.7
24 to 30	2	10.0	8	10.3	25	17.0	8	8.2	6	21.4	49	13.2
17 to 23	5	25.0	19	24.4	26	17.7	17	17.5	7	25.0	74	20.0
10 to 16	6	30.0	15	19.2	28	19.0	20	20.6	6	21.4	75	20.3
3 to 9	1	5.0	15	19.2	29	19.7	17	17.5	4	14.3	66	17.8
-4 to 2	6	30.0	17	21.8	26	17.7	23	23.7	1	3.6	73	19.7
-11 to -5	0	-	4	5.1	6	4.1	9	9.3	0	-	19	5.1
TOTAL	20	100.0	78	100.0	147	100.0	97	99.9	28	99.9	370	99.9
MEAN	11.6		10.7		12.6		9.5		18.1		11.7	
S. D.	± 10.05		± 10.07		±10.99		± 11.06		± 9.37		± 10.83	

RESTRICTED
Security Information

RESTRICTED
Security Information

APPENDIX TABLE 120

COMPARISON OF CLIMATIC REGIONS WITH RESPECT TO MINIMUM TEMPERATURE OF EXPOSURE AMONG 256 NEGRO FROSTBITE CASES
KOREA, 1951-52

(°F) Minimum Temperature of Exposure	Climatic Region I No.	I %	II No.	II %	III No.	III %	IV No.	IV %	V No.	V %	Total No.	Total %
More than 37	0	-	0	-	0	-	0	-	0	-	0	-
31 to 37	0	-	2	10.5	4	3.4	3	2.8	0	-	9	3.5
24 to 30	0	-	3	15.8	28	24.1	17	16.0	4	28.6	52	20.3
17 to 23	0	-	6	31.6	20	17.2	28	26.4	4	28.6	58	22.7
10 to 16	1	100.0	2	10.5	20	17.2	17	16.0	5	35.7	45	17.6
3 to 9	0	-	5	26.3	20	17.2	13	12.3	1	7.1	39	15.2
-4 to 2	0	-	0	-	20	17.2	18	17.0	0	-	38	14.8
-11 to -5	0	-	1	5.3	4	3.4	10	9.4	0	-	15	5.9
TOTAL	1	100.0	19	100.0	116	99.7	106	99.9	14	100.0	256	100.0
MEAN	13.0		16.7		14.0		12.5		18.5		13.8	
S. D.	-		± 11.34		± 11.29		±11.73		± 7.08		± 11.32	

RESTRICTED
Security Information

APPENDIX TABLE 121

COMPARISON OF CLIMATIC REGIONS WITH RESPECT TO MINIMUM TEMPERATURE OF EXPOSURE AMONG 392 WHITE BUNKER-MATE CONTROLS
KOREA, 1951-52

(°F) Minimum Temperature of Exposure	Climatic Region I No.	I %	II No.	II %	III No.	III %	IV No.	IV %	V No.	V %	Total No.	Total %
More than 37	0	-	0	-	0	-	0	-	1	4.2	1	0.3
31 to 37	3	7.9	2	1.7	5	3.8	4	4.8	0	-	14	3.6
24 to 30	6	15.8	16	13.9	27	20.6	15	17.9	4	16.7	68	17.3
17 to 23	10	26.3	28	24.3	27	20.6	16	19.0	9	37.5	90	23.0
10 to 16	4	10.5	21	18.3	21	16.0	10	11.9	9	37.5	65	16.6
3 to 9	2	5.3	8	7.0	18	13.7	13	15.5	1	4.2	42	10.7
-4 to 2	11	28.9	34	29.6	22	16.8	19	22.6	0	-	86	21.9
-11 to -5	2	5.3	6	5.2	11	8.4	7	8.3	0	-	26	6.6
TOTAL	38	100.0	115	100.0	131	99.9	84	100.0	24	100.1	392	100.0
MEAN	13.2		11.3		13.1		11.8		16.7		12.5	
S. D.	± 12.69		± 11.33		± 12.00		± 12.35		± 8.17		± 11.82	

RESTRICTED
Security Information

APPENDIX TABLE 122

COMPARISON OF CLIMATIC REGIONS WITH RESPECT TO MINIMUM TEMPERATURE OF EXPOSURE AMONG 36 NEGRO BUNKER-MATE CONTROLS
KOREA, 1951-52

(°F) Minimum Temperature of Exposure	Climatic Region											
	I		II		III		IV		V		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
More than 37	0	-	0	-	0	-	0	-	0	-	0	-
31 to 37	0	-	0	-	0	-	1	8.3	0	-	1	2.8
24 to 30	0	-	0	-	2	20.0	0	-	7	53.8	9	25.0
17 to 23	0	-	0	-	2	20.0	3	25.0	2	15.4	7	19.4
10 to 16	0	-	0	-	3	30.0	2	16.7	4	30.8	9	25.0
3 to 9	0	-	1	100.0	2	20.0	2	16.7	0	-	5	13.9
-4 to 2	0	-	0	-	1	10.0	1	8.3	0	-	2	5.6
-11 to -5	0	-	0	-	0	-	3	25.0	0	-	3	8.3
TOTAL	0	-	1	100.0	10	100.0	12	100.0	13	100.0	36	100.0
MEAN	-		6.0		14.4		8.9		21.6		14.9	
S. D.	-		-		± 9.71		± 14.10		± 6.75		± 11.02	

RESTRICTED
Security Information

APPENDIX TABLE 123

COMPARISON OF CLIMATIC REGIONS WITH RESPECT TO DURATION OF EXPOSURE AMONG 674 FROSTBITE CASES KOREA, 1951-52

Duration of Exposure	Climatic Region I		II		III		IV		V		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
0 - 4 hrs.	5	25.0	45	40.9	98	35.7	85	38.6	17	34.0	250	37.0
4.1 - 8 hrs.	4	20.0	26	23.6	70	25.5	60	27.3	13	26.0	173	25.7
8.1 - 12 hrs.	5	25.0	20	18.2	43	15.6	30	13.6	11	22.0	109	16.2
12.1 - 16 hrs.	1	5.0	5	4.5	26	9.5	12	5.5	3	6.0	47	6.9
16.1 - 20 hrs.	1	5.0	1	0.9	2	0.7	4	1.8	1	2.0	9	1.3
20.1 - 24 hrs.	0	-	5	4.5	15	5.5	9	4.1	0	-	29	4.3
2 days	1	5.0	3	2.7	13	4.7	9	4.1	2	4.0	28	4.2
3 days	2	10.0	3	2.7	2	0.7	5	2.3	0	-	12	1.8
Over 3 days	1	5.0	2	1.8	5	1.8	6	2.7	3	6.0	17	2.5
TOTAL	20	100.0	110	99.8	274	99.7	220	100.0	50	100.0	674	99.9
MEAN	17.8		10.0		10.2		10.9		12.1		10.7	
S. D.	± 24.00		± 14.97		± 13.68		± 16.43		± 19.47		± 15.69	

APPENDIX TABLE 124

COMPARISON OF CLIMATIC REGIONS WITH RESPECT TO DURATION OF EXPOSURE AMONG 450 BUNKER-MATE CONTROLS
KOREA, 1951-52

Duration of Exposure	Climatic Region											
	I		II		III		IV		V		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
0 - 4 hrs.	8	20.5	41	35.3	46	31.0	44	43.5	13	28.3	152	33.8
4.1 - 8 hrs.	15	38.5	29	25.0	42	28.4	34	33.7	6	13.0	126	28.0
8.1 - 12 hrs.	12	30.8	23	19.8	25	16.9	7	6.9	12	26.0	79	17.6
12.1 - 16 hrs.	2	5.1	10	8.6	16	10.8	7	6.9	2	4.3	37	8.2
16.1 - 20 hrs.	0	-	2	1.7	3	2.0	3	2.9	0	-	8	1.8
20.1 - 24 hrs.	0	-	7	6.0	5	3.3	2	2.0	2	4.3	16	3.6
2 days	1	2.6	3	2.6	5	3.3	1	1.0	4	8.7	14	3.1
3 days	0	-	0	-	1	0.6	2	2.0	3	6.5	6	1.3
Over 3 days	1	2.6	1	0.8	5	3.3	1	1.0	4	8.7	12	2.7
TOTAL	39	100.1	116	99.8	148	99.6	101	99.9	46	99.8	450	100.1
MEAN	9.6		8.7		11.1		7.9		19.9		10.5	
S. D.	± 13.38		± 10.75		± 16.00		± 12.05		± 25.05		± 15.29	

RESTRICTED
Security Information

APPENDIX TABLE 125

COMPARISON OF CLIMATIC REGIONS WITH RESPECT TO SITE OF INJURY
AMONG 406 WHITE FROSTBITE CASES
KOREA, 1951-52

Site of Injury	Climatic Region											
	I		II		III		IV		V		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
One hand only	0	-	4	4.4	5	3.3	8	7.4	0	-	17	4.2
One foot only	2	9.5	9	9.8	13	8.6	7	6.5	1	2.9	32	7.9
Both hands	0	-	9	9.8	12	7.9	13	12.0	3	8.8	37	9.1
Both feet	16	76.2	60	65.9	94	61.8	62	57.4	24	70.6	256	63.0
One hand and one foot	0	-	0	-	0	-	1	0.9	0	-	1	0.2
Both hands and both feet	3	14.3	5	5.5	13	8.6	8	7.4	5	14.7	34	8.4
One hand and both feet	0	-	1	1.1	5	3.3	4	3.7	1	2.9	11	2.7
One foot and both hands	0	-	0	-	2	1.3	2	1.9	0	-	4	0.9
Other (ears, nose)	0	-	3	3.3	8	5.3	3	2.8	0	-	14	3.4
TOTAL	21	100.0	91	99.8	152	100.1	108	100.0	34	99.9	406	99.8

Chi square = 26.077 df = 32 P = .76

RESTRICTED
Security Information

RESTRICTED
Security Information

APPENDIX TABLE 126

COMPARISON OF CLIMATIC REGIONS WITH RESPECT TO SITE OF INJURY AMONG 284 NEGRO FROSTBITE CASES KOREA, 1951-52

Site of Injury	Climatic Region											
	I		II		III		IV		V		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
One hand only	0	-	1	4.3	6	4.7	5	4.2	0	-	12	4.2
One foot only	0	-	1	4.3	8	6.3	16	13.4	3	21.4	28	9.9
Both hands	0	-	5	21.7	14	11.0	13	10.9	0	-	32	11.3
Both feet	1	100.0	12	52.2	8[illegible]	66.1	70	58.8	10	71.4	177	62.3
One hand & one foot	0	-	0	-	0	-	1	0.8	1	7.1	2	0.7
Both hands & both feet	0	-	3	13.0	12	9.4	8	6.[illegible]	0	-	23	8.0
One hand & both feet	0	-	0	-	1	0.8	4	3.4	0	-	8	1.8
One foot & both hands	0	-	0	-	0	-	1	0.8	0	-	1	0.4
Other (ears, nose)	0	-	1	4.3	2	1.6	1	0.8	0	-	4	1.4
TOTAL	1	100.0	23	99.8	127	99.9	119	99.8	14	99.9	284	100.0

Chi square = 29.895 df = 32 P = .58

RESTRICTED
Security Information

RESTRICTED
Security Information

APPENDIX TABLE 127

MEAN SCHOOL GRADE COMPLETED BY 114 FROSTBITE CASES AND 1343 PRE-EXPOSURE CONTROLS ACCORDING TO RACE AND CLIMATIC REGION OF ORIGIN
KOREA, 1951-52

Region and Race	School Grade Completed					
	Cases			Controls		
	No.	Mean Grade	S.D.	No.	Mean Grade	S.D.
North White	14	11.79	± 2.0015	437	10.45	± 2.0261
South White	35	10.20	± 1.7857	711	9.98	± 2.2401
North Negro	7	10.86	± 1.3123	12	10.75	± 1.4855
South Negro	58	10.26	± 1.9348	183	9.93	± 1.9836
Total White	49	10.65	± 1.9436	1148	10.16	± 2.1729
Total Negro	65	10.32	± 1.8738	195	9.98	± 1.9611

APPENDIX TABLE 128

COMPARISONS (t) OF MEAN SCHOOL GRADE COMPLETED BY 114 FROSTBITE CASES AND 1343 PRE-EXPOSURE CONTROLS
KOREA, 1951-52

Comparison	Difference in Mean	t	P
North White Control vs South White Control	0.47	3.663	<.01
North Negro Control vs South Negro Control	0.82	1.809	>.05
North White Case vs South White Case	1.59	2.588	<.01
North Negro Case vs South Negro Case	0.60	1.076	>.20
North White Control vs North White Case	1.34	2.465	<.02
South White Control vs South White Case	0.22	0.702	>.30
North Negro Control vs North Negro Case	0.11	0.167	>.80
South Negro Control vs South Negro Case	0.33	1.125	>.20
Reg. II White Control vs Reg. II White Case	1.23	2.249	<.05
Reg. III White Control vs Reg. III White Case	0.34	0.700	>.40
Reg. IV White Control vs Reg. IV White Case	0.23	0.416	>.60
Reg. V White Control vs Reg. V White Case	0.75	0.759	>.40
Reg. II Negro Control vs Reg. II Negro Case	0.13	0.190	>.80
Reg. III Negro Control vs Reg. III Negro Case	0.58	1.381	>.10

RESTRICTED
Security Information

APPENDIX TABLE 129

MEAN AGCT SCORES (AREA I) AMONG 71 FROSTBITE CASES AND 1,114 PRE-EXPOSURE CONTROLS DISTRIBUTED ACCORDING TO RACE AND REGION OF ORIGIN
KOREA, 1951-52

Region	White						Negro					
	Cases			Control			Cases			Control		
	No.	Mean Score	S. D.	No.	Mean Score	S. D.	No.	Mean Score	S. D.	No.	Mean Score	S. D.
I	0	-	-	106	102.69	± 17.19	0	-	-	1	75.00	-
II	6	103.50	± 20.04	241	97.18	± 19.08	2	58.50	-	9	78.67	± 13.34
III	10	93.80	± 18.80	381	92.44	± 19.41	19	77.05	± 18.13	126	71.13	± 12.18
IV	9	87.78	± 14.27	178	91.96	± 9.91	24	71.46	± 11.47	52	70.06	± 13.06
V	1	57.00	-	20	83.40	± 16.43	0	-	-	0	-	-
Total	26	92.54	± 18.45	926	94.67	± 17.92	45	73.24	±14.41	188	71.21	± 12.51

APPENDIX TABLE 130

MEAN AGCT SCORES (AREA III) AMONG 71 FROSTBITE CASES AND 1,302 PRE-EXPOSURE CONTROLS DISTRIBUTED ACCORDING TO RACE AND REGION OF ORIGIN KOREA, 1951-52

Region	White						Negro					
	Cases			Control			Cases			Control		
	No.	Mean Score	S. D.	No.	Mean Score	S. D.	No.	Mean Score	S. D.	No.	Mean Score	S. D.
I	0	-	-	117	100.89	± 19.04	0	-	-	1	68.00	-
II	6	104.67	± 19.98	307	98.18	± 18.67	2	58.50	-	9	[illegible]7.78	± 11.45
III	10	93.10	± 20.20	459	92.93	± 18.61	19	76.53	± 19.69	126	7[illegible].39	± 13.73
IV	9	87.11	± 15.38	210	89.53	± 19.15	24	71.71	± 14.61	53	[illegible]0.28	± 13.44
V	1	55.00	-	20	87.95	± 14.43	0	-	-	0	-	-
Total	26	92.23	± 19.57	1113	94.49	± 19.08	45	73.16	± 16.41	189	70.70	± 13.55

RESTRICTED
Security Information

RESTRICTED
Security Information

RESTRICTED
Security Information

APPENDIX TABLE 131

MEAN AGCT SCORES (AREA I) AMONG 71 FROSTBITE CASES AND 1114 PRE-EXPOSURE CONTROLS DISTRIBUTED ACCORDING TO RACE AND REGION OF ORIGIN
KOREA, 1951-52

Region and Race	AGCT Score -- Area I					
	Cases			Controls		
	No.	Mean Score	S.D.	No.	Mean Score	S.D.
North White	6	103.50	± 20.04	347	98.86	± 18.69
South White	20	89.25	± 17.58	579	92.15	± 16.95
North Negro	2	58.50	-	10	78.30	± 12.56
South Negro	43	73.93	± 14.33	178	70.81	± 12.46
Total White	26	92.54	± 18.45	926	94.67	± 17.92
Total Negro	45	73.24	± 14.41	188	71.21	± 12.51

APPENDIX TABLE 132

MEAN AGCT SCORES (AREA III) AMONG 71 FROSTBITE CASES AND 1302 PRE-EXPOSURE CONTROLS DISTRIBUTED ACCORDING TO RACE AND REGION OF ORIGIN
KOREA, 1951-52

Region and Race	AGCT Score -- Area III					
	Cases			Controls		
	No.	Mean Score	S.D.	No.	Mean Score	S.D.
North White	6	104.67	± 19.93	424	98.93	± 18.61
South White	20	88.50	± 18.74	689	91.75	± 18.73
North Negro	2	58.50	-	10	76.80	± 11.21
South Negro	43	73.24	± 16.40	179	70.36	± 13.64
Total White	26	92.23	± 19.57	1113	94.49	± 19.08
Total Negro	'5	73.16	± 16.41	189	70.70	± 13.55

RESTRICTED
Security Information

RESTRICTED
Security Information

APPENDIX TABLE 133

"t" COMPARISONS OF MEAN AGCT SCORES (AREA I) FOR 71 FROSTBITE CASES AND 1114 PRE-EXPOSURE CONTROLS KOREA, 1951-52

Comparison	Difference in Mean	t	P
North White Control vs South White Control	6.71	5.473	<.01
North White Cases vs South White Cases	14.25	1.569	>.10
North Negro Control vs South Negro Control	7.49	1.835	>.05
North White Control vs North White Cases	4.64	0.562	>.60
South White Control vs South White Cases	2.90	0.726	>.40
South Negro Control vs South Negro Cases	3.12	1.312	>.10
North White Control vs North Negro Control	20.56	5.018	<.01
South White Cases vs South Negro Cases	15.32	3.406	<.01
South White Control vs South Negro Control	21.34	18.248	<.01

APPENDIX TABLE 134

"t" COMPARISONS OF MEAN AGCT SCORES (AREA III) FOR 71 FROSTBITE CASES AND 1302 PRE-EXPOSURE CONTROLS KOREA, 1951-52

Comparison	Difference in Mean	t	P
North White Control vs South White Control	7.18	6.193	<.01
North White Cases vs South White Cases	16.17	1.763	>.05
North Negro Control vs South Negro Control	6.44	1.746	>.05
North Negro Cases vs South Negro Cases	15.34	1.407	>.10
North White Control vs North White Cases	5.74	0.699	>.40
South White Control vs South White Cases	3.25	0.764	>.40
South Negro Control vs South Negro Cases	3.48	1.288	>.10
North Negro Control vs North Negro Cases	18.30	1.636	>.10
North White Control vs North Negro Control	22.13	6.046	<.01
South White Control vs South Negro Control	21.39	17.187	<.01
North White Cases vs North Negro Cases	46.17	3.450	<.01
South White Cases vs South Negro Cases	14.66	3.004	<.01

RESTRICTED
Security Information

RESTRICTED
Security Information

APPENDIX TABLE 135

COMPARISON OF CLIMATIC REGIONS WITH RESPECT TO PERSONAL HYGIENE
AMONG 1279 WHITE PRE-EXPOSURE CONTROLS
KOREA, 1951-52

Personal Hygiene	Climatic Region											
	I		II		III		IV		V		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Excellent	21	15.4	65	18.7	79	15.0	40	16.1	1	5.6	206	16.1
Good	98	72.0	252	72.4	406	76.8	177	71.0	15	83.3	948	74.1
Poor	17	12.5	31	8.9	43	8.1	32	12.9	2	11.1	125	9.8
TOTAL	136	99.9	348	100.0	528	99.9	249	100.0	18	100.0	1279	100.0

Chi square = 8.111 df = 8 P >.30

APPENDIX TABLE 136

COMPARISON OF CLIMATIC REGIONS WITH RESPECT TO PERSONAL HYGIENE
AMONG 275 NEGRO PRE-EXPOSURE CONTROLS
KOREA, 1951-52

Personal Hygiene	Climatic Region											
	I		II		III		IV		V		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Excellent	0	-	2	8.3	5	3.0	7	8.1	0	-	14	5.1
Good	0	-	16	66.6	121	73.3	66	76.7	0	-	203	73.8
Poor	0	-	6	25.0	39	23.6	13	15.1	0	-	[illegible]	21.1
TOTAL	0	-	24	99.9	165	99.9	86	99.9	0	-	275	100.0

Chi square = 5.850 df = 4 P >.20

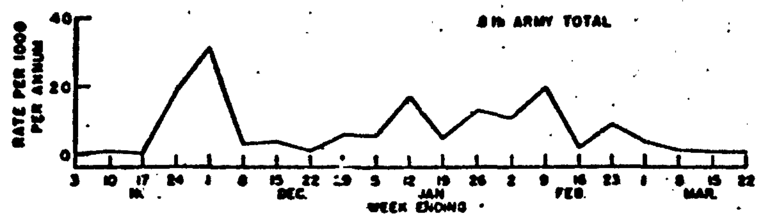
RESTRICTED
Security Information

RESTRICTED
Security Information

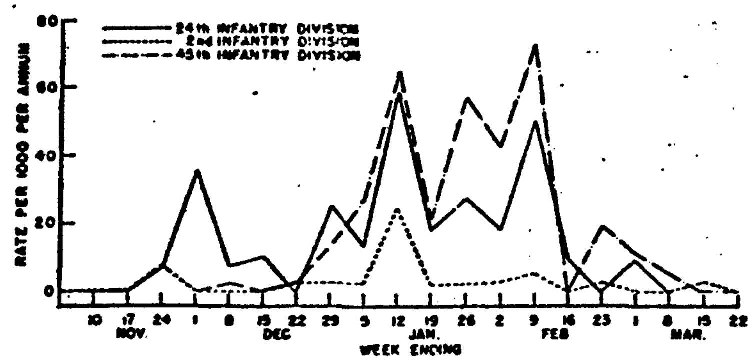
APPENDIX II

MISCELLANEOUS EPIDEMIOLOGIC FIGURES

RESTRICTED
Security Information

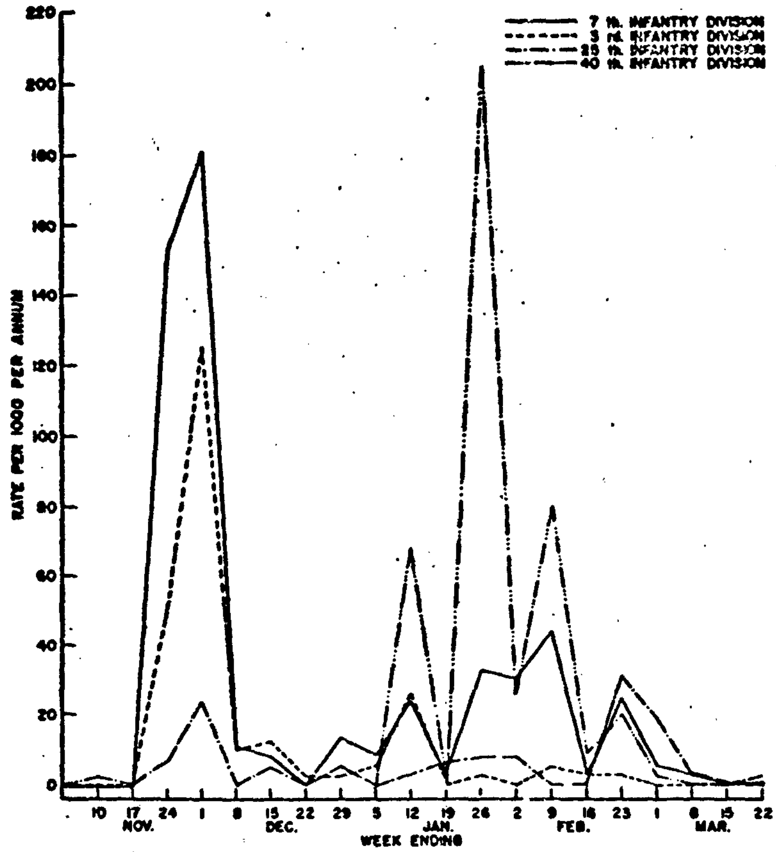


APPENDIX FIGURE I COLD INJURY-KOREA, 1951-52
WEEKLY RATE PER 1000 ANNUM FOR ENTIRE 8th ARMY.



APPENDIX FIGURE II COLD INJURY-KOREA, 1951-1952
WEEKLY RATE PER 1000 PER ANNUM FOR 2nd, 24th AND 45th DIVISIONS.

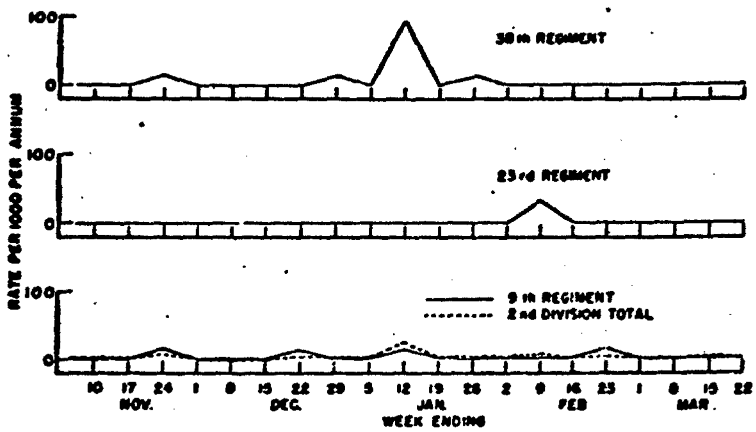
RESTRICTED
Security Information



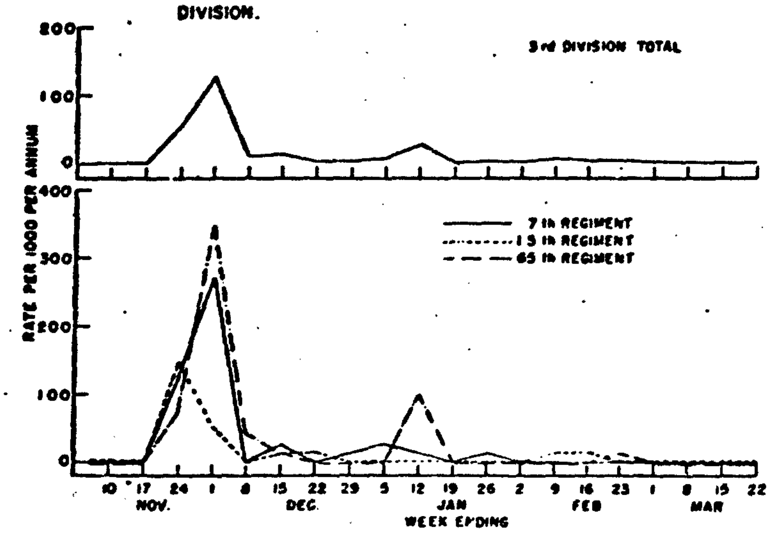
APPENDIX FIGURE III COLD INJURY—KOREA, 1951-52.
WEEKLY RATE PER 1000 PER ANNUM FOR 3rd, 7th, 25th. AND 40th. DIVISIONS.

RESTRICTED
Security Information

RESTRICTED
Security Information

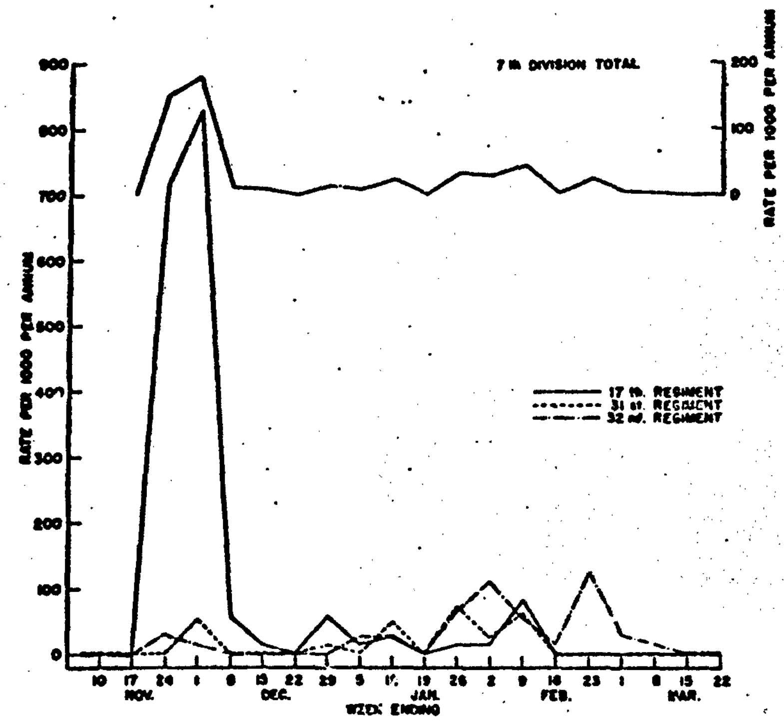


APPENDIX FIGURE IX COLD INJURY-KOREA, 1951-52.
WEEKLY RATE PER 1000 PER ANNUM FOR 2nd INFANTRY DIVISION.

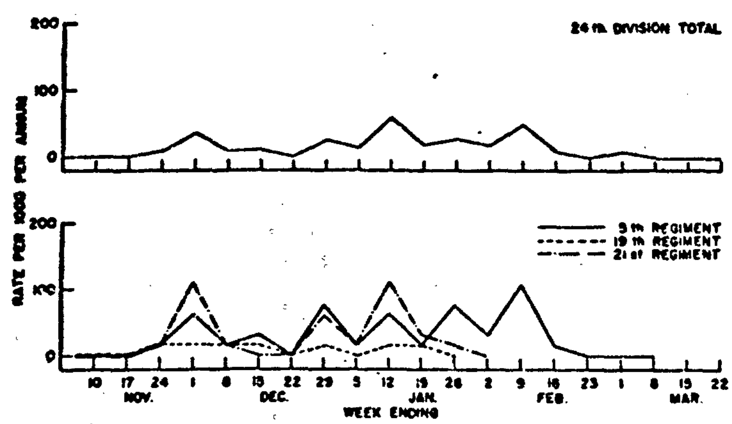


APPENDIX FIGURE X COLD INJURY-KOREA, 1951-52.
WEEKLY RATE PER 1000 PER ANNUM FOR 3rd INFANTRY DIVISION.

RESTRICTED
Security Information

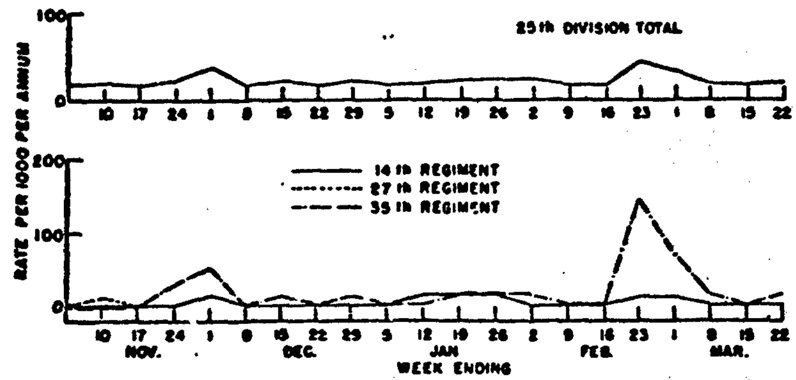


APPENDIX FIGURE VI COLD INJURY-KOREA, 1951-52.
WEEKLY RATE PER 1000 PER ANNUM FOR 7th. INFANTRY DIVISION.

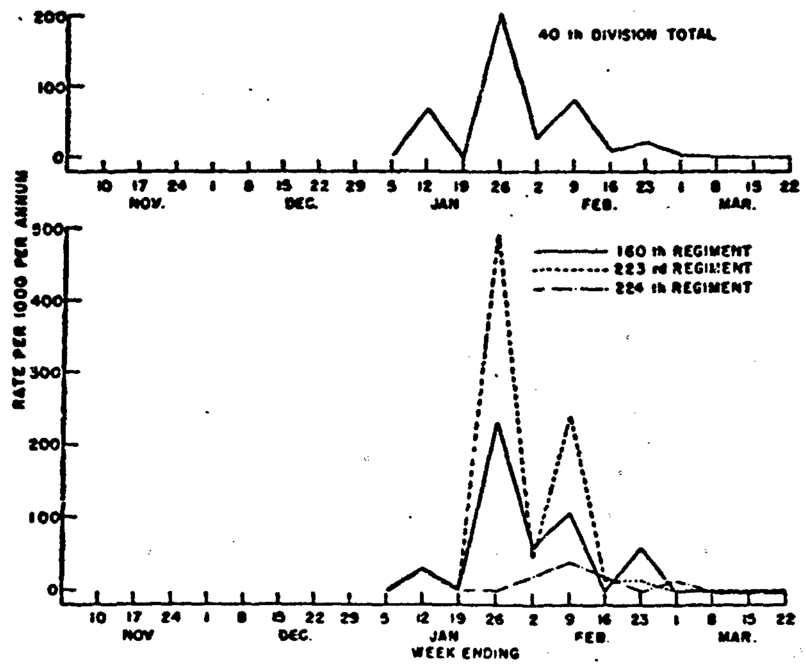


APPENDIX FIGURE VII COLD INJURY-KOREA, 1951-52.
WEEKLY RATE PER 1000 PER ANNUM FOR 24th. INFANTRY DIVISION.

RESTRICTED
Security Information

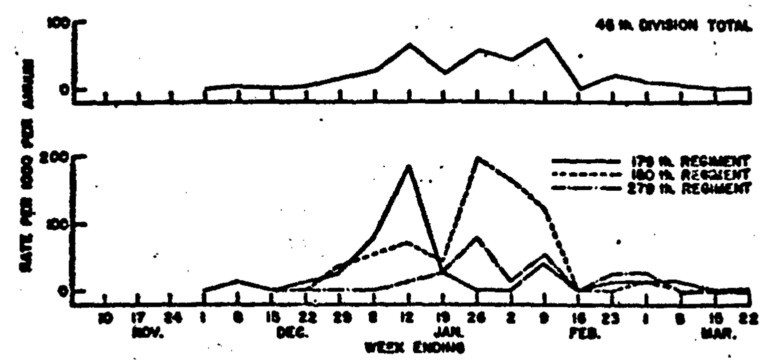


APPENDIX FIGURE XIII COLD INJURY-KOREA, 1951-52.
WEEKLY RATE PER 1000 PER ANNUM FOR 25th INFANTRY DIVISION

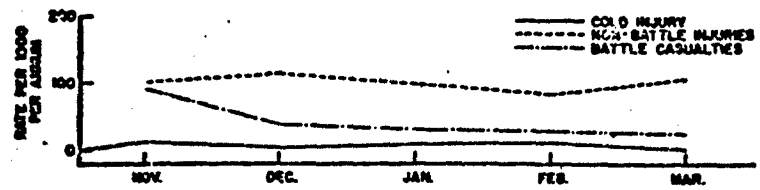


APPENDIX FIGURE IX COLD INJURY-KOREA, 1951-52.
WEEKLY RATE PER 1000 PER ANNUM FOR 40th INFANTRY DIVISION

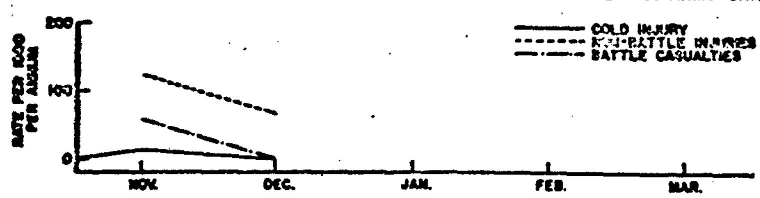
RESTRICTED
Security Information



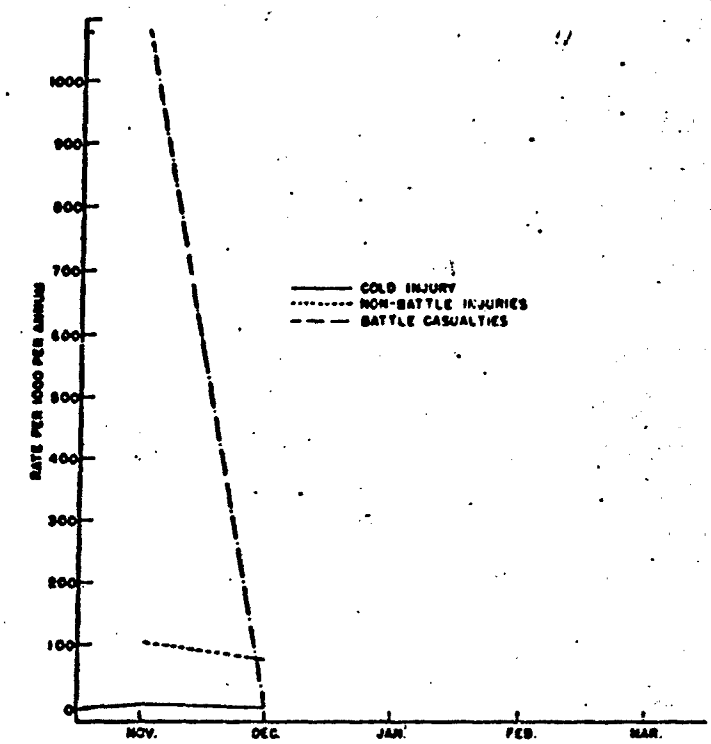
APPENDIX FIGURE X COLD INJURY-KOREA, 1951-52.
WEEKLY RATE PER 1000 PER ANNUM FOR 45 th. INFANTRY DIVISION.



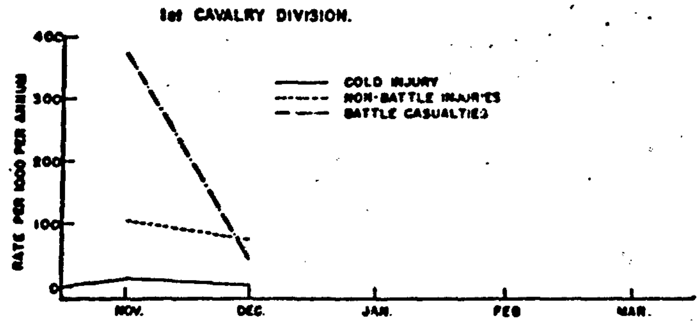
APPENDIX FIGURE XI COLD INJURY, BATTLE CASUALTIES, NON-BATTLE INJURIES (EXCLUSIVE OF COLD INJURY)-1951-52.
MONTHLY RATE PER 1000 PER ANNUM FOR TOTAL 8th. ARMY UNITS.



APPENDIX FIGURE XII COLD INJURY, BATTLE CASUALTIES, NON-BATTLE INJURIES (EXCLUSIVE OF COLD INJURY)-1951-52.
MONTHLY RATE PER 1000 PER ANNUM FOR 5 th. REGIMENT-1st. CALVARY DIVISION.

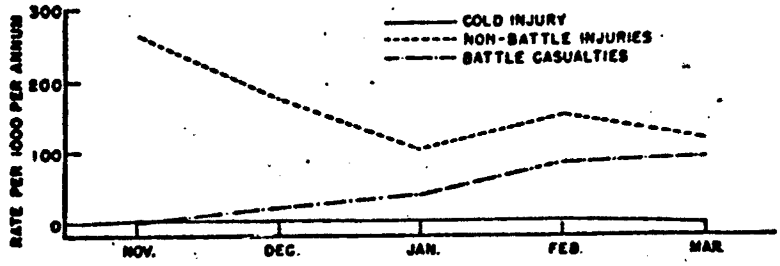


APPENDIX FIGURE XIII COLD INJURY, BATTLE CASUALTIES, NON-BATTLE INJURIES (EXCLUSIVE OF COLD INJURY) - 1951-52.
MONTHLY RATE PER 1000 PER ANNUM FOR 7th REGIMENT-1st CAVALRY DIVISION.



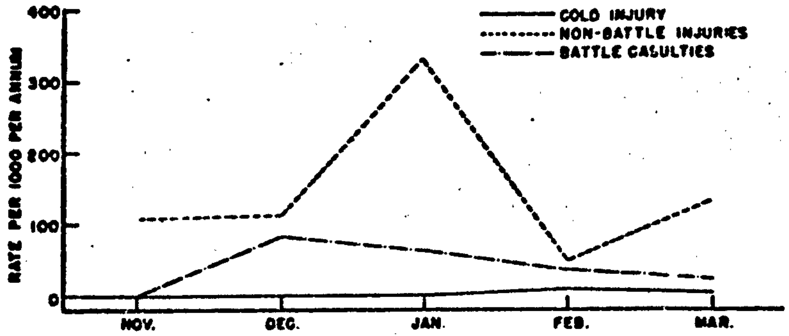
APPENDIX FIGURE XIX COLD INJURY, BATTLE CASUALTIES, NON-BATTLE INJURIES (EXCLUSIVE OF COLD INJURY)-1951-52.
MONTHLY RATE PER 1000 PER ANNUM FOR 8th REGIMENT-1st CAVALRY DIVISION.

RESTRICTED
Security Information



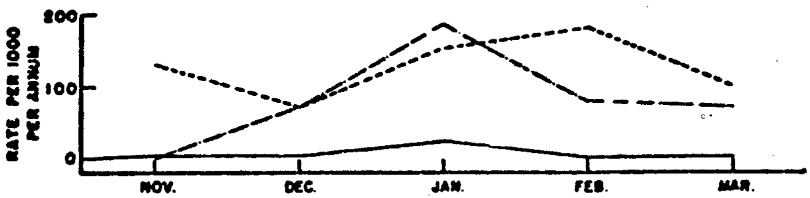
APPENDIX FIGURE XV COLD INJURY, BATTLE CASUALTIES, NON-BATTLE INJURIES (EXCLUSIVE OF COLD INJURY)-1951-52

MONTHLY RATE PER 1000 PER ANNUM FOR 9th REGIMENT-2nd INFANTRY DIVISION



APPENDIX FIGURE XVI COLD INJURY, BATTLE CASUALTIES, NON-BATTLE INJURIES (EXCLUSIVE OF COLD INJURY)-1951-52.

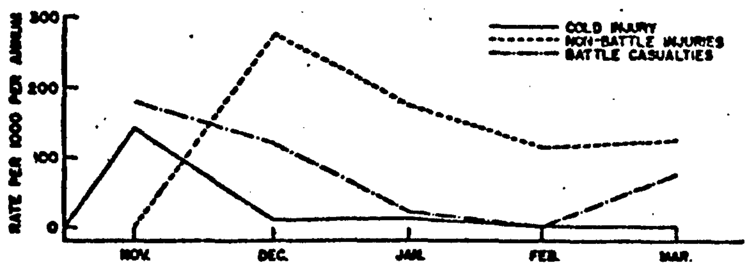
MONTHLY RATE PER 1000 PER ANNUM FOR 23rd REGIMENT-2nd INFANTRY DIVISION.



APPENDIX FIGURE XVII COLD INJURY, BATTLE CASUALTIES, NON-BATTLE INJURIES (EXCLUSIVE OF COLD INJURY)-1951-52.

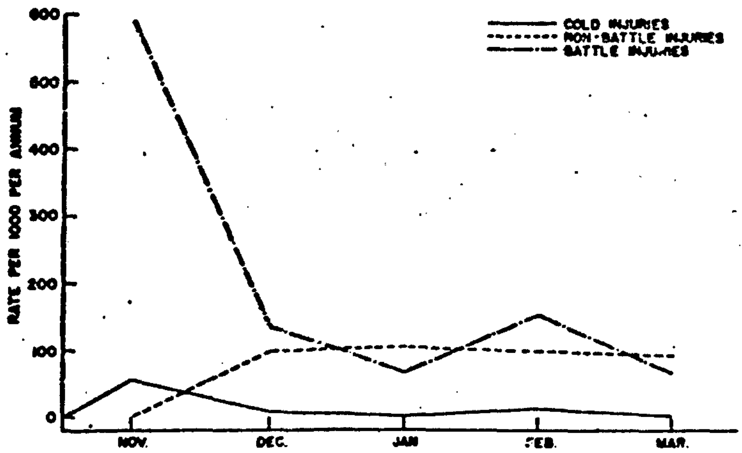
MONTHLY RATE PER 1000 PER ANNUM FOR 38th REGIMENT-2nd INFANTRY DIVISION.

RESTRICTED
Security Information



APPENDIX FIGURE XVIII COLD INJURY, BATTLE CASUALTIES, NON-BATTLE INJURIES (EXCLUSIVE OF COLD INJURY)-1951-52.

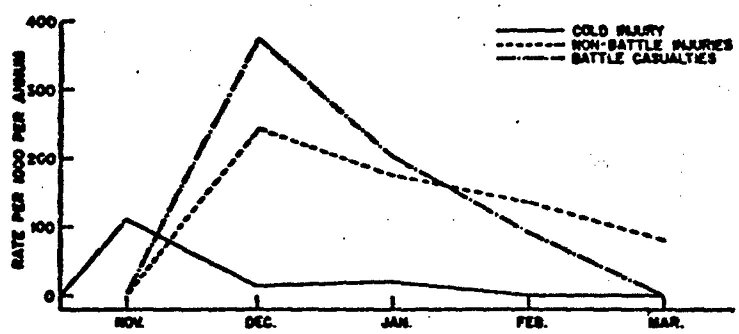
MONTHLY RATE PER 1000 PER ANNUM FOR 7th. REGIMENT-3rd. INFANTRY DIVISION.



APPENDIX FIGURE XIX COLD INJURY, BATTLE CASUALTIES, NON BATTLE INJURIES (EXCLUSIVE OF COLD INJURY)-1951-52.

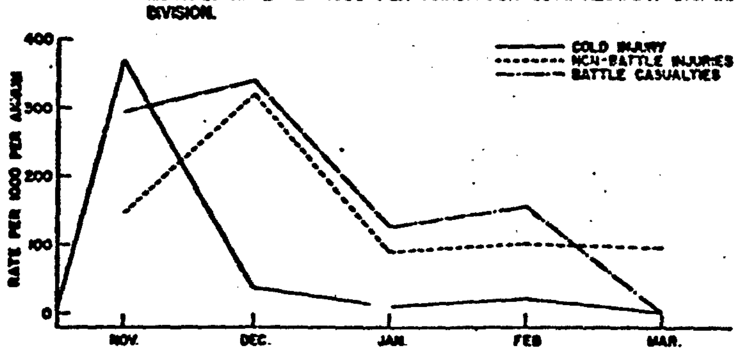
MONTHLY RATE PER 1000 PER ANNUM FOR 15th. REGIMENT-3rd. INFANTRY DIVISION.

RESTRICTED
Security Information



APPENDIX FIGURE XX COLD INJURY, BATTLE CASUALTIES, NON-BATTLE INJURIES (EXCLUSIVE OF COLD INJURY)-1951-52.

MONTHLY RATE PER 1000 PER ANNUM FOR 65th. REGIMENT-3rd. INFANTRY DIVISION.

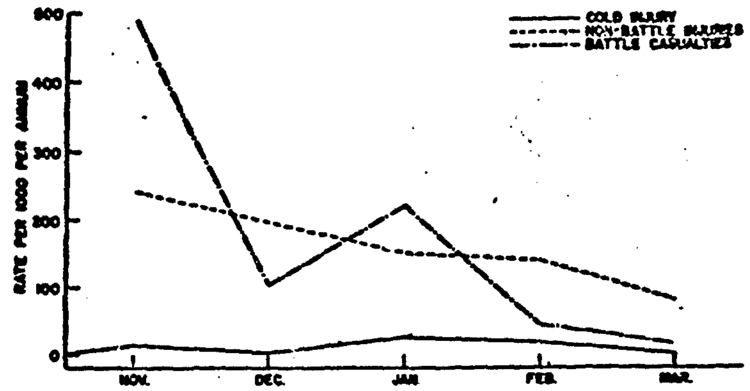


APPENDIX FIGURE XXI COLD INJURY, BATTLE CASUALTIES, NON BATTLE INJURIES (EXCLUSIVE OF COLD INJURY)-1951-52.

MONTHLY RATE PER 1000 PER ANNUM FOR 17th. REGIMENT-7th. INFANTRY DIVISION.

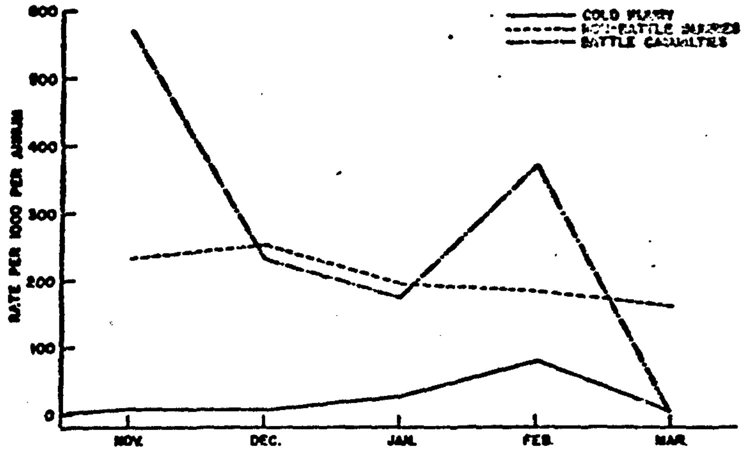
RESTRICTED
Security Information

RESTRICTED
Security Information



APPENDIX FIGURE [illegible] COLD INJURY, BATTLE CASUALTIES, NON-BATTLE INJURIES (EXCLUSIVE OF COLD INJURY)-1951-52.

MONTHLY RATE PER 1000 PER ANNUM FOR 31st. REGIMENT-7th. INFANTRY DIVISION.

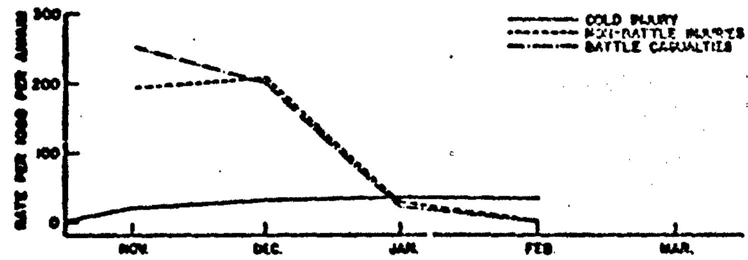


APPENDIX FIGURE [illegible] COLD INJURY, BATTLE CASUALTIES, NON-BATTLE INJURIES (EXCLUSIVE OF COLD INJURY)-1951-52.

MONTHLY RATE PER 1000 PER ANNUM FOR 32nd. REGIMENT-7th. INFANTRY DIVISION.

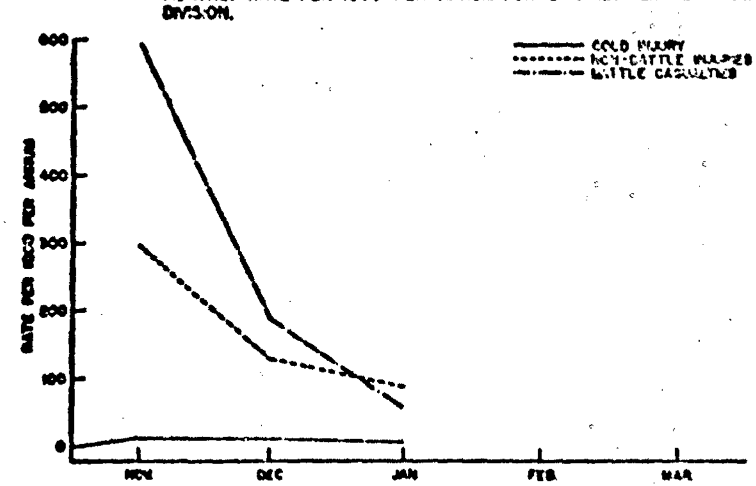
RESTRICTED
Security Information

RESTRICTED
Security Information



APPENDIX FIGURE [illegible] COLD INJURY, BATTLE CASUALTIES, NON-BATTLE INJURIES (EXCLUSIVE OF COLD INJURY)-1951-52.

MONTHLY RATE PER 1000 PER ANNUM FOR 5th. REGIMENT-24th. INFANTRY DIVISION.

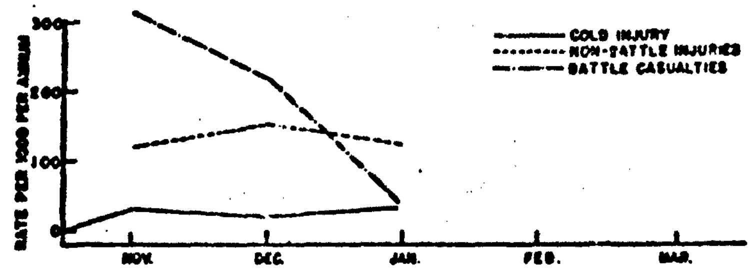


APPENDIX FIGURE [illegible] COLD INJURY, BATTLE CASUALTIES, NON-BATTLE INJURIES (EXCLUSIVE OF COLD INJURY)-1951-52.

MONTHLY RATE PER 1000 PER ANNUM FOR 19th. REGIMENT-24th. INFANTRY DIVISION.

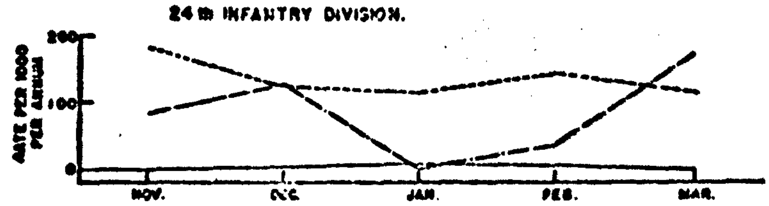
RESTRICTED
Security Information

RESTRICTED
Security Information



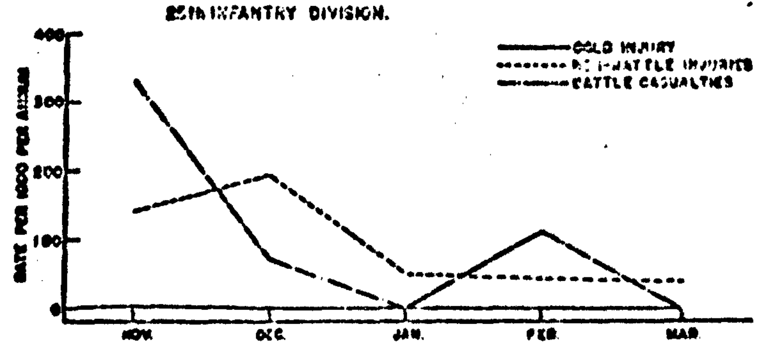
APPENDIX FIGURE [illegible] COLD INJURY, BATTLE CASUALTIES, NON-BATTLE INJURIES (EXCLUSIVE OF COLD INJURY)-1951-52.

MONTHLY RATE PER 1000 PER ANNUM FOR 21st REGIMENT—24th INFANTRY DIVISION.



APPENDIX FIGURE [illegible] COLD INJURY, BATTLE CASUALTIES, NON-BATTLE INJURIES (EXCLUSIVE OF COLD INJURY)-1951-52.

MONTHLY RATE PER 1000 PER ANNUM FOR 14th REGIMENT—25th INFANTRY DIVISION.

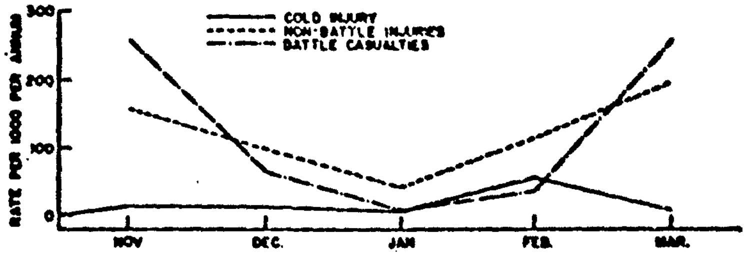


APPENDIX FIGURE [illegible] COLD INJURY, BATTLE CASUALTIES, NON-BATTLE INJURIES (EXCLUSIVE OF COLD INJURY)-1951-52.

MONTHLY RATE PER 1000 PER ANNUM FOR 27th REGIMENT—25th INFANTRY DIVISION.

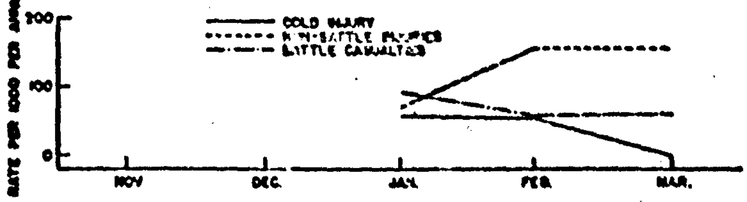
RESTRICTED
Security Information

RESTRICTED
Security Information



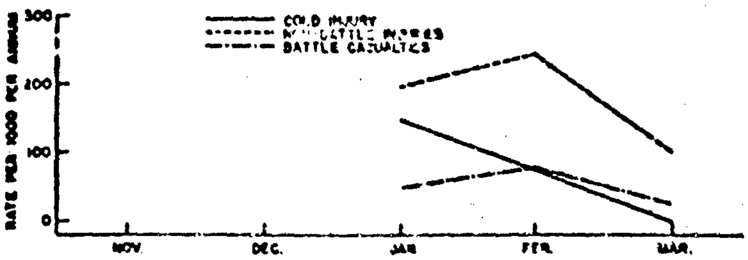
APPENDIX FIGURE XXIX COLD INJURY, BATTLE CASUALTIES, NON-BATTLE INJURIES (EXCLUSIVE OF COLD INJURY)-1951-52.

MONTHLY RATE PER 1000 PER ANNUM FOR 35th REGIMENT-27th INFANTRY DIVISION.



APPENDIX FIGURE XXX COLD INJURY, BATTLE CASUALTIES, NON-BATTLE INJURIES (EXCLUSIVE OF COLD INJURY)-1951-52.

MONTHLY RATE PER 1000 PER ANNUM FOR 160th REGIMENT-40th INFANTRY DIVISION.

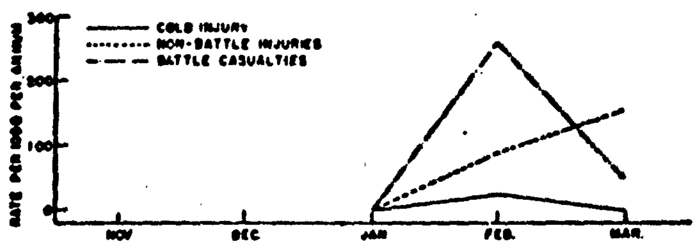


APPENDIX FIGURE XXXI COLD INJURY, BATTLE CASUALTIES, NON-BATTLE INJURIES (EXCLUSIVE OF COLD INJURY)-1951-52.

MONTHLY RATE PER 1000 PER ANNUM FOR 223rd REGIMENT-40th INFANTRY DIVISION.

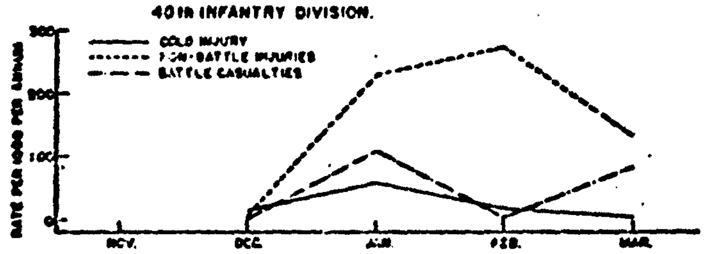
RESTRICTED
Security Information

RESTRICTED
Security Information



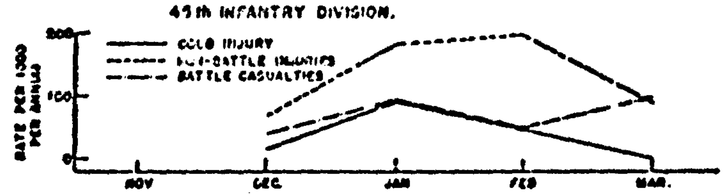
APPENDIX FIGURE [illegible] COLD INJURY, BATTLE CASUALTIES, NON-BATTLE INJURIES (EXCLUSIVE OF COLD INJURY)-1951-52.

MONTHLY RATE PER 1000 PER ANNUM FOR 224th REGIMENT-40th INFANTRY DIVISION.



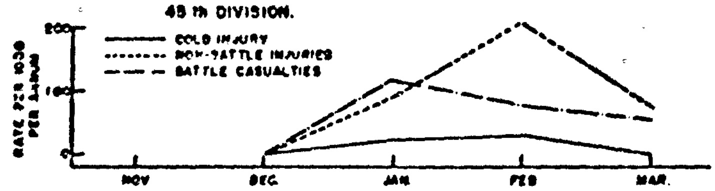
APPENDIX FIGURE [illegible] COLD INJURY, BATTLE CASUALTIES, NON-BATTLE INJURIES (EXCLUSIVE OF COLD INJURY)-1951-52.

MONTHLY RATE PER 1000 PER ANNUM FOR 179th REGIMENT-45th INFANTRY DIVISION.



APPENDIX FIGURE [illegible] COLD INJURY, BATTLE CASUALTIES, NON-BATTLE INJURIES (EXCLUSIVE OF COLD INJURY)-1951-52.

MONTHLY RATE PER 1000 PER ANNUM FOR 180th REGIMENT-45th DIVISION.



RESTRICTED
Security Information

APPENDIX FIGURE [illegible] COLD INJURY, BATTLE CASUALTIES, NON-BATTLE INJURIES (EXCLUSIVE OF COLD INJURY)-1951-52.

MONTHLY RATE PER 1000 PER ANNUM FOR 279th REGIMENT-45th INFANTRY DIVISION.

ARMY MEDICAL RESEARCH LABORATORY

FORT KNOX, KENTUCKY

REPORT NO. 113
1 April 1953

COLD INJURY - KOREA 1951-52*

Section V
A CLINICAL EVALUATION OF FROSTBITE, KOREA, 1951-52

*Subtask under Environmental Physiology, AMRL Project No. 6-64-12-028, Subtask (8K), Cold Injury Studies.

MEDICAL RESEARCH AND DEVELOPMENT BOARD
OFFICE OF THE SURGEON GENERAL
DEPARTMENT OF THE ARMY

SECTION V

A CLINICAL EVALUATION OF FROSTBITE

KOREA, 1951-52

by

Kenneth D. Orr
Lt. Col., MC, USA

TABLE OF CONTENTS

A CLINICAL EVALUATION OF FROSTBITE
KOREA, 1951-52

I. INTRODUCTION

The winter of 1951-52, unlike the previous winter, found the United States troops engaged in a holding action with their offensive tactics limited to patrols ranging from squad to company size. Also the protection of the individual soldier against inclement weather was improved because of better shelters, newer types of protective clothing and more promt logistical support. In spite of these improvements 716 cases of authenticated frostbite occurred among the United States troops.

The classification of frostbite lesions used in 1950-51 was again utilized for the 1951-52 cases. This classification is based upon tissue changes produced by the effect of cold and divides the injuries into four degrees of severity:

1. First degree frostbite is characterized by numbness, erythema, swelling and superficial desquamation of the involved part.
2. Second degree frostbite produces vesiculation of the skin. This injury involves only partial thickness of the skin and does not extend into the subcutaneous tissue.
3. Third degree frostbite involves the entire thickness of skin extending into varying depths of subcutaneous tissue. In these lesions vesicles may or may not appear.

4. Fourth degree frostbite causes sufficient injury to the entire thickness of the part including bone so that loss is inevitable.

The clinical classification of frostbite presently in use lacks an index to the amount of area involved. A classification has not yet been devised which includes the degree of injury and area of involvement. Until such a classification is formulated complete evaluations and comparisons of the causative factors, healing time, efficacy of frostbite treatment, etc., cannot be made.

Between 20 November 1951 and 15 March 1952, 716 confirmed cases of frostbite were admitted to the cold injury centers in Korea and Japan for treatment and disposition.

A comparison of the frostbite cases of 1951-52 with those of 1950-51 revealed a shift in the degree of severity (Table 1). In 1950-51 the severity rate was; first degree 16.7%, second degree 33.6%, third degree 43.6% and fourth degree 6.1%. In 1951-52 cases showed an increase in first degree to 39.0%, second degree remaining approximately the same at 36.4%, while third and fourth degrees dropped to 20.0 and 4.6% respectively. This decrease in degree of severity was due to static combat conditions, milder weather and better individual protection against the environment.

Similarly a shift in anatomical sites of involvement by frostbite was noted. In the 1950-51 cold injury cases* the percentage of feet injured by frostbite was 87.4%, hands 12.2% and heads (ears-nose)

*Orr, K. D. and D. C. Fainer, "Cold Injuries in Korea During Winter of 1950-51". Medicine Vol. 31, No. 2, pp 117-220, May 1952.

TABLE 1

DISTRIBUTION OF FROSTBITE CASES BY
DEGREE OF INJURY FOR 1950-51 AND 1951-52

Degree of Maximum Injury	No. of Cases		Percent	
	1950-51*	1951-52	1950-51	1951-52
First	314	279	16.7	39.0
Second	632	261	33.6	36.4
Third	819	143	43.6	20.0
Fourth	115	33	6.1	4.6
Total	1880	716	100.1	100.0

*These are for cases admitted to Osaka Army Hospital

0.4%. In 1951-52 there was a lowering of the frequency of frostbite of the feet to 74.4% and an increase in hands and heads (ear-nose) to 23.2 and 2.4% respectively (Table 1A).

TABLE 1A

DISTRIBUTION OF 716 CASES OF FROSTBITE BY DEGREE
OF SEVERITY AND ANATOMICAL SITE OF INJURY

Degree of Injury	Feet - 74.4%		Hands - 23.2%		Ears - Nose - 2.4%		Total	
	No.	%	No.	%	No.	%	No.	%
First	254	43.1	86	46.7	6	31.6	346	43.7
Second	177	30.1	75	40.8	13	68.4	265	33.5
Third	131	22.2	13	7.1	0	0	144	18.2
Fourth	27	4.6	10	5.4	0	0	37	4.7
Total	589	100.0	184	100.0	19	100.0	792*	100.0

*Includes cases where both hands
and feet in the same individual were injured

The racial incidence of frostbite of the feet for United States

troops in 1951-52 had a percentage distribution of 59 and 41% for White and Negro soldiers respectively. The distribution for frostbite of the hands was 58.6% for Whites and 41.4% for Negroes (Table 2). Among 585 cases with frostbite of the feet the Negro soldier had a higher percentage of third and fourth degree involvement than the White. This same pattern except for fourth degree injuries was found in 181 cases with frostbite of the hand.

TABLE 2

DISTRIBUTION OF 705 CASES OF FROSTBITE - RACE, DEGREE OF INJURY AND ANATOMICAL LOCATION OF INJURY

Degree of Injury	Feet				Hands			
	White - 59%		Negro - 41%		White - 58.6%		Negro - 41.4%	
	No. of Cases	%	No. of Cases	%	No. of Cases	%	No. of Cases	%
First	164	47.5	87	36.2	58	54.7	27	36.0
Second	109	31.6	68	28.3	37	34.9	36	48.0
Third	58	16.8	72	30.0	4	3.8	9	12.0
Fourth	14	4.1	13	5.4	[illegible]	6.6	3	4.0
Total	345	100.0	240	99.9	106	100.0	75	100.0

The sites of maximum involvement for 578 patients with frostbite of the feet varied according to the degree of severity. In first, second and third degree lesions the most common site was the great toe. In fourth degree frostbite all toes were more often involved than one single toe (Table 3). Irrespective of degree of injury, the great toe was more frequently involved (53.5%) than any other single toe, combination of toes or parts of the foot. There was no consistent site of maximum involvement for 325 single hands injured by frostbite when

TABLE 3

DISTRIBUTION OF 578 CASES OF FROSTBITE OF THE FOOT, BY SITE OF MAXIMUM INJURY AND DEGREE OF INJURY

Site of Maximum Injury	Degree of Injury									
	First		Second		Third		Fourth		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%
First Toe	75	30.6	137	77.8	94	72.3	3	11.1	309	53.5
Second Toe	0	0	7	4.0	4	3.1	1	3.7	12	2.1
Fifth Toe	9	3.7	6	3.4	4	3.1	0	0	19	3.3
First, Second Toes	11	4.5	4	2.3	13	10.0	3	11.1	31	5.4
First, Fifth Toes	2	0.8	5	2.9	2	1.5	1	3.7	10	1.7
Third, Fourth, Fifth Toes	0	0	0	0	2	1.5	0	0	2	0.3
First, Second, Third Toes	4	1.6	1	0.6	4	3.1	2	7.4	11	1.9
First, Second, Third, Fourth Toes	2	0.8	0	0	1	0.6	2	7.4	5	0.9
All Toes	63	25.7	8	4.5	3	2.3	10	37.0	84	14.5
Heel	3	1.2	4	2.3	1	0.8	0	0	8	1.4
All Toes and Heel	6	2.4	0	0	0	0	3	11.1	9	1.6
One Toe and Heel	0	0	2	1.1	1	0.8	0	0	3	0.5
Two or More Toes and Heel	0	0	0	0	0	0	0	0	0	0
Distal Third	37	15.1	1	0.6	1	0.8	1	3.7	40	6.9
Entire Foot	33	13.5	1	0.6	0	0	1	3.7	35	6.1
Total	245	99.9	176	100.0	130	100.0	27	99.9	578	100.0

classified by degree of severity. Irrespective of degree of injury, however, 56.9% of the frostbitten hands had more than two finger tips injured by cold (Table 4).

II. CLINICAL MANIFESTATIONS

The clinical manifestations of frostbite injuries have been described for the cases that occurred in 1950-51*. The frostbite patients of 1951-52 had a similar pattern of clinical manifestations. There was no dissimilarity in the clinical course of the two groups of frostbite cases.

Certain factors which contributed to the clinical course of frostbite were not previously considered in the analysis of the 1950-51 cases but an opportunity presented itself in the winter of 1951-52 to do so. These factors included: degree of injury, anatomical site of involvement, race, duration of cold exposure, methods of rewarming, type of footgear worn, type of handgear worn, condition of the extremity at time of injury and type of treatment. Two clinical aspects of frostbite lend themselves as criteria for evaluation of the restoration of cold damaged tissues: 1) the drying time of vesicles and 2) the healing time of the lesions.

The drying time of vesicles was defined as the number of days (from time of injury) required to complete the process of drying. Drying was considered to be primarily dependent upon the status of circulation around the base of the vesicle. A

*Orr, K. D. and D. C. Fainer. Cold Injuries in Korea during the winter of 1950-51. Medicine. 31: 117-220, May 1952.

TABLE 4

SITES OF MAXIMUM INJURY FOR 325 HANDS WITH FROSTBITE
BY DEGREE OF SEVERITY

Site of Maximum Injury	Degree of Injury									
	First		Second		Third		Fourth		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%
One Fingertip	18	11.8	8	6.0	4	17.4	1	6.3	31	9.5
Two Fingertips	15	9.9	23	17.2	1	4.3	0	0	39	12.0
More than Two Fingertips	116	76.3	56	41.8	7	30.4	6	37.5	185	56.9
Dorsum of One Finger	2	1.3	7	5.2	0	0	1	6.3	10	3.1
Dorsum of Two Fingers	1	0.7	6	4.5	1	4.3	0	0	8	2.5
Dorsum of more than Two Fingers	0	0	34	25.4	10	43.5	8	50.0	52	16.0
Total	152	100.0	134	100.1	23	99.9	16	100.1	325	100.0

vesicle of either second or third degree was considered to be completely dried when its contents had been reabsorbed, and no break or leakage from the vesicle wall had existed throughout the entire period of drying. The top of the vesicle at time of completion of drying formed a firm, dry, tough eschar.

Healing time was defined as the number of days (from time of injury) required to complete the healing process. The healing of frostbite lesions was considered to be complete when the following criteria were fulfilled.

1. First Degree

   The involved part no longer showed signs of edema or erythema and superficial desquamation of the skin was almost completed.

2. Second Degree

   The eschar derived from the dried vesicle was sloughed and the underlying intact epithelium sufficiently keratinized so that it would not break down when the patient was allowed to be ambulatory.

3. Third Degree

   The eschar overlying the lesion had sloughed and the earlier underlying ulceration extending into the subcutaneous tissue was covered by intact new skin sufficiently keratinized so as to allow the patient to be ambulatory.

4. Fourth Degree

   No healing time could be determined since healing

of these lesions had to be dependent upon the time that elective surgical intervention was instituted.

III. AN EVALUATION OF FACTORS THAT MAY ALTER THE DRYING AND HEALING TIMES OF FROSTBITE LESIONS

A. Degree of Injury and Anatomical Site

The anatomical site of the injury and its degree of severity must be considered when evaluating the different drying times of vesicles. The mean time required for the drying of vesicles of second degree frostbite was 12.2 days for injuries of the feet alone, 10.2 days for feet and hands combined in the same patient and 13.9 days for injuries of the hands alone (Table 5). Comparisons between these means showed them not to be significantly different. The mean vesicular drying times for hands and feet with third degree lesions were not significantly different. There was, however, a significant difference between the drying time of second and third degree vesicles of the feet but not in the case of hands.

It was concluded from the results of the comparisons shown in Table 5, that the drying time of vesicles depended upon the degree of injury and not upon the anatomical site.

The time required for healing of frostbite lesions also was evaluated according to their anatomical site and degree of severity. The mean healing time for feet

TABLE 5

COMPARISON OF MEAN DRYING TIME OF VESICLES FOR 227 CASES OF FROSTBITE WITH RESPECT TO DEGREE OF INJURY AND ANATOMICAL SITE OF INVOLVEMENT

Degree of Injury	Site of Involvement	No. of Cases	Mean Drying Time (Days)	Standard Deviation	t	P
Second Second	Feet Hands	99 33	12.2 13.9	± 7.28 ± 6.51	1.244	>.20
Second Second	Feet Feet & Hands	99 17	12.2 10.2	± 7.28 ± 4.94	1.453	>.10
Third Third	Feet Hands	66 12	19.9 15.6	± 9.50 ±10.20	1.356	>.10
Second Third	Feet Feet	99 66	12.2 19.9	± 7.28 ± 9.50	5.551	<.001
Second Third	Hands Hands	33 12	13.9 15.6	± 6.51 ±10.20	0.539	>.50

irrespective of degree of injury was 36 days, which proved to be significantly longer than the mean of 24.4 days for hands (Table 6). When the hands and feet were grouped together the mean days required for healing of first degree was 21.3 days, second degree 23.7 days and third degree 53.0 days. There was no significant difference between the mean healing time of first and second degree lesions. There was, however, a significant difference between first and third, and second and third degree lesions. Comparisons between mean healing times of hands and feet within the same degree of injury showed that only in second degree was there a significant difference. From these comparisons in addition to others in Table 6 it was concluded:

1) Second degree frostbite of the feet takes longer to

heal than do hand lesions of like degree;

2) The healing time of first and second degree lesions regardless of anatomical site are not significantly different.

3) The healing time for third degree lesions of the feet was significantly longer than for first and second degree.

TABLE 6

COMPARISON OF MEAN HEALING TIME FOR 318 CASES OF FIRST, SECOND AND THIRD DEGREE FROSTBITE OF THE FEET AND HANDS

Degree of Injury	Part Involved	No. of Cases	Mean Healing Time (Days)	Standard Deviation	t	P
Combined Combined	Feet Hands	222 59	36.0 24.4	±21.04 ±12.95	5.267	<.001
First Second	Combined Combined	36 173	21.3 23.7	±13.51 ± 9.95	1.019	>.30
First Third	Combined Combined	36 109	21.3 53.0	±13.51 ±21.40	10.408	<.001
Second Third	Combined Combined	173 109	23.7 53.0	± 9.95 ±21.40	13.396	<.001
First Second	Feet Feet	28 104	20.6 25.3	±14.60 ±10.33	1.599	>.20
First Third	Feet Feet	23 90	20.6 53.2	±14.60 ±20.17	9.345	<.001
Second Third	Feet Feet	104 90	25.3 53.2	±10.33 ±20.17	11.826	<.001
First Second	Hands Hands	4 49	22.8 21.7	±11.13 ± 8.07	0.190	>.80
First Third	Hands Hands	4 6	22.8 48.0	±11.13 ±25.46	2.142	>.05
Second Third	Hands Hands	49 6	21.7 48.0	± 8.07 ±25.46	2.518	<.02
First First	Feet Hands	28 4	20.6 22.8	±14.60 ±11.13	0.345	>.60
Second Second	Feet Hands	104 49	25.3 21.7	±10.33 ± 8.07	2.372	<.02
Third Third	Feet Hands	90 6	53.2 48.0	±20.17 ±25.46	0.486	>.60

B. Race

The drying time and healing time in second and third degree frostbite were evaluated with respect to race, anatomical site and degree of injury. The mean days required to dry second degree vesicles of the feet for the Whites was 12.6 and for the Negroes 12.8 (Table 7). Second degree vesicles of hands had a mean drying time in Whites of 14.2 days and in Negroes 13.8 days. The third degree lesions of feet had a mean vesicular drying time for Whites of 17.8 days and Negroes 21.1 days. When the degree of injury was kept constant comparisons of the above means between race and anatomical sites yielded no statistically significant differences. The only significant changes in drying time occurred between degree of injury. The factor of race did not influence the drying time of vesicles of frostbite.

To elicit racial differences in the healing times 142 White and 136 Negro frostbite cases were compared (Table 8). Regardless of anatomical site or degree of severity of frostbite lesions the mean healing time for Negro soldiers was significantly higher than for the White soldiers. The explanation for this difference may be found in Table 2 where it has been shown that the Negro soldiers incurred higher percentages of third and fourth degree frostbite. There were no significant differences in healing times between the races when comparisons were

TABLE 7

COMPARISON OF THE MEAN DRYING TIME OF VESICLES FOR 196 CASES OF FROSTBITE OF THE FEET WITH RESPECT TO DEGREE OF INJURY, RACE, AND SITE OF INVOLVEMENT

Degree of Injury	Site of Involvement	Race	No. of Cases	Mean Drying Time (Days)	Standard Deviation	t	P
Second Second	Feet Hands	White White	61 17	12.6 14.2	± 6.50 ± 7.09	0.853	>.30
Second Third	Feet Feet	White White	61 23	12.6 17.8	± 6.50 ± 7.90	2.801	<.01
Second Second	Feet Hands	Negro Negro	38 15	12.8 13.8	± 6.99 ± 6.86	0.456	>.60
Second Third	Feet Feet	Negro Negro	38 42	12.8 21.1	± 6.99 ±10.28	4.263	<.001
Second Second	Feet Feet	White Negro	61 38	12.6 12.8	± 6.50 ± 6.99	0.160	>.80
Second Second	Hands Hands	White Negro	17 15	14.2 13.8	± 7.09 ± 6.86	0.140	>.80
Third Third	Feet Feet	White Negro	23 42	17.8 21.1	± 7.90 ±10.28	1.470	>.10
Second Second	Feet Hands	White Negro	61 15	12.6 13.8	± 6.50 ± 6.86	0.600	>.50
Second Second	Hands Feet	White Negro	17 38	14.2 12.8	± 7.09 ± 6.99	0.680	>.40
Second Third	Feet Feet	White Negro	61 42	12.6 21.1	± 6.50 ±10.28	4.760	<.001
Second Third	Hands Feet	White Negro	17 42	14.2 21.1	± 7.09 ±10.28	2.805	<.01

made of frostbite lesions having like degrees of injury and anatomical sites of involvement. This was also the case when the racial comparisons were made between lesions of like degree irrespective of anatomical site. Earlier evaluations (Table 6) showed that irrespective of race there was a significantly shorter healing time for second degree frostbite of the hands as compared to like lesions of the feet. However, when these same

comparisons were made with respect to race the Negro patients failed to show a significant difference. The healing time of a frostbite lesion was not dependent upon the race of the patient.

TABLE 8

COMPARISON OF MEAN HEALING TIME FOR 278 CASES OF FROSTBITE WITH RESPECT TO DEGREE OF INJURY, ANATOMICAL SITE AND RACE

Degree of Injury	Race	Part Injured	No. of Cases	Mean Healing Time (Days)	Standard Deviation	t	P
Combined	White	Combined	142	30.4	±17.97	2.865	<.01
Combined	Negro	Combined	136	37.2	±21.69		
First	White	Combined	19	21.3	±16.54	0.051	>.90
First	Negro	Combined	12	21.5	± 9.69		
Second	White	Combined	66	23.9	± 9.33	0.456	>.60
Second	Negro	Combined	66	24.7	±10.33		
Third	White	Combined	37	50.1	±19.52	1.119	>.20
Third	Negro	Combined	58	54.8	±20.63		
First	White	Feet	18	21.9	±16.80	0.422	>.60
First	Negro	Feet	9	19.7	±10.37		
Second	White	Feet	61	25.3	± 9.72	0.038	>.90
Second	Negro	Feet	43	25.3	±11.13		
Third	White	Feet	36	50.4	±19.73	1.156	>.20
Third	Negro	Feet	53	55.3	±20.31		
Second	White	Hands	25	20.4	± 7.49	1.308	>.20
Second	Negro	Hands	23	23.5	± 8.90		
Second	White	Feet	61	25.3	± 9.72	2.515	<.02
Second	White	Hands	25	20.4	± 7.49		
Second	Negro	Feet	43	25.3	±11.13	0.716	>.40
Second	Negro	Hands	23	23.5	± 8.90		

C. Duration of Exposure

The duration of cold exposure of the frostbite casualties was evaluated so as to determine its influence upon the clinical course of the injury. The duration of exposure

was defined as the number of hours the patient was exposed to a low ambient temperature during which time he developed a cold injury. The onset of exposure was considered that time when the soldier either became immobile (pinned down) or noted the onset of numbness of an extremity which subsequently showed positive signs of frostbite. In order to measure exposure time on the basis of numbness, this complaint must have progressed to a state where the area of involvement imparted to the soldier the sensation of "being like a block of wood".

Exposure to cold was terminated at the time the immobile (pinned down) soldier became mobile (walking), and/or when the numbness of the involved extremity disappeared.

An attempt was made to divide the cases into two equal groups so as to illustrate the existence of differences, if any, in the drying time and healing time of frostbite lesions in relation to duration of exposure. Since the most nearly accurate designation of exposure time was in intervals of 4 hours the closest group which would contain 50% of the cases was 0 to 8 hours. Actually 62.9% of the 716 cases of frostbite were represented by the exposure interval up to and including 8 hours.

The cold exposure time for 216 cases of second and third degree frostbite ranged between 1 and 72 hours. Regardless of duration of exposure the mean drying time

of vesicles among second degree frostbite cases was significantly shorter than for cases of third degree (Table 9). The mean vesicular drying time for patients with second degree frostbite who had a cold exposure of 0 to 8 hours was 11.8 days. This drying time was significantly lower than the mean drying time of 14.6 days attained by cases of like degree of injury but with an exposure time of 8.1 to 72 hours. In third degree frostbite there was no significant difference between the mean drying time of vesicles with a cold exposure of 1 to 8 hours, and those with an exposure of 8.1 to 72 hours. Second degree vesicles resulting from a cold exposure of 8.1 to 72 hours required almost as much time to dry as did third degree vesicles with a 1 to 8 hour exposure. The conclusions derived from Table 9 were:

1) The drying time of second degree vesicles was dependent upon the duration of exposure, i.e., the longer the exposure, the greater was the vesicular drying time.
2) The drying time of third degree vesicles was not altered by the different duration of exposures.

The time required for the healing of 213 cases of frostbite of the feet was also evaluated according to the length of cold exposure. The only significant prolongation of healing as a result of an increase in

TABLE 9

COMPARISON OF MEAN DRYING TIME OF VESICLES FOR 216 CASES OF FROSTBITE WITH RESPECT TO DEGREE OF INJURY AND THE DURATION OF COLD EXPOSURE

Degree of Injury	Exposure Time (Hours)	No. of Cases	Mean Drying Time (Days)	Standard Deviation	t	P
Second Third	0 - 72 0 - 72	142 74	12.7 19.4	±6.59 ±9.61	5.335	<.001
Second Second	0 - 8 8.1 - 72	97 45	11.8 14.6	±6.33 ±6.76	2.312	<.02
Third Third	0 - 8 8.1 - 72	41 33	17.9 21.2	±9.39 ±9.56	1.525	>.10
Second Third	0 - 8 0 - 8	97 41	11.8 17.9	±6.33 ±9.39	3.776	<.001
Second Third	0 - 8 8.1 - 72	97 33	11.8 21.2	±6.33 ±9.56	5.274	<.001
Second Third	8.1 - 72 0 - 8	45 41	14.6 17.9	±6.76 ±9.39	1.841	>.05
Second Third	8.1 - 72 8.1 - 72	45 33	14.6 21.2	±6.76 ±9.56	3.413	<.01

exposure time occurred in second degree frostbite lesions of the feet (Table 10). The mean healing time of these lesions resulting from a 1 to 8 hour exposure was 24.1 days, as compared to a mean of 28.8 days for the 8.1 to 72 hour exposure group.

First degree frostbite lesions of the feet resulting from a cold exposure of 8.1 to 72 hours required almost as much time to heal as did second degree lesions with an exposure of 1 to 8 hours. On the other hand, first degree lesions of the feet of the 1 to 8 hour exposure group had a mean healing time of 19.1 days, which was significantly shorter than the 8.1 to 72 hour

TABLE 10

A COMPARISON OF MEAN HEALING TIMES OF 213 CASES
OF FROSTBITE OF THE FEET WITH RESPECT TO DEGREE
OF INJURY AND DURATION OF COLD EXPOSURE

Degree of Injury	Exposure Time (Hours)	No. of Cases	Mean Healing Time (Days)	Standard Deviation	t	P
First Second	0 - 72 0 - 72	28 99	20.6 25.4	±14.60 ±10.39	1.637	>.10
First Third	0 - 72 0 - 72	28 86	20.6 52.6	±14.60 ±19.91	9.142	<.001
Second Third	0 - 72 0 - 72	99 86	25.4 52.6	±10.39 ±19.91	11.363	<.001
First First	0 - 8 8.1 - 72	17 11	19.1 22.9	± 9.45 ±21.25	0.557	>.60
Second Second	0 - 8 8.1 - 72	70 29	24.1 28.8	±10.13 ±10.63	2.026	<.05
Third Third	0 - 8 8.1 - 72	51 35	51.9 53.5	±19.01 ±21.11	0.368	>.70
First Second	0 - 8 0 - 8	17 70	19.1 24.1	± 9.45 ±10.13	1.910	>.05
First Second	0 - 8 8.1 - 72	17 29	19.1 28.8	± 9.45 ±10.63	3.[illegible]37	<.01
First Third	0 - 8 0 - 8	17 51	19.1 51.9	± 9.45 ±19.01	9.329	<.001
First Third	0 - 8 8.1 - 72	17 35	19.1 53.5	± 9.45 ±21.11	8.114	<.001
First Second	8.1 - 72 0 - 8	11 70	22.9 24.1	±21.25 ±10.13	0.178	>.80
First Second	8.1 - 72 8.1 - 72	11 29	22.9 28.8	±21.25 ±10.63	0.872	>.30
First Third	8.1 - 72 0 - 8	11 51	22.9 51.9	±21.25 ±19.01	4.177	<.001
First Third	8.1 - 72 8.1 - 72	11 35	22.9 53.5	±21.25 ±21.11	4.176	<.001
Second Third	0 - 8 0 - 8	70 51	24.1 51.9	±10.12 ±19.01	9.515	<.001
Second Third	0 - 8 8.1 - 72	70 35	24.1 53.5	±10.12 ±21.11	7.820	<.001
Second Third	8.1 - 72 0 - 8	29 51	28.8 51.9	±10.63 ±19.01	6.982	<.001
Second Third	8.1 - 72 8.1 - 72	29 35	28.8 53.5	±10.63 ±21.11	6.076	<.001

second degree lesions of the feet whose mean was 28.8 days. These differences in healing times of first and second degree frostbite of the feet were not evident in the other types of comparisons shown in Tables 6 and 8. The different cold exposure times did not significantly alter the mean healing times of first and third degree frostbite of the feet. It is postulated that because of prolonged cold exposure first degree lesions of the feet were almost identical to second degree lesions with regard to their rate of healing, although tissue changes indicative of second degree were not present.

The healing time of 58 cases of frostbite of the hands were compared on the basis of their degree of severity and duration of exposure (Table 11). Regardless of the degree of injury the healing time of hand lesions resulting from an exposure of 1 to 8 hours was not significantly different than those cases with a cold exposure of 8.1 to 72 hours. Forty-five cases with second degree of the hands with an exposure of 1 to 8 hours had a mean healing time that was not significantly different from three cases with an exposure of over 8 hours. The comparisons of healing times for hands as shown in Table 11 indicate that the duration of exposure was not an influencing factor in the healing of this type of frostbite injury.

TABLE 11

COMPARISON OF MEAN HEALING TIMES OF 58 CASES OF FROSTBITE OF THE HANDS WITH RESPECT TO DEGREE OF INJURY AND DURATION OF COLD EXPOSURE

Degree of Injury	Exposure Time (Hours)	No. of Cases	Mean Healing Time (Days)	Standard Deviation	t	P
First	0 - 72	4	22.8	±11.13	0.143	>.80
Second	0 - 72	48	21.9	± 7.94		
First	0 - 72	4	22.8	±11.13	2.142	>.05
Third	0 - 72	6	48.0	±25.46		
Second	0 - 72	48	22.8	± 7.94	2.493	<.02
Third	0 - 72	6	48.0	±25.46		
Combined	0 - 8	54	24.5	±12.37	0.200	>.80
Combined	8.1 - 72	4	27.0	±24.62		
Second	0 - 8	45	22.3	± 7.97	1.196	>.05
Second	8.1 - 72	3	16.7	± 7.87		
Third	0 - 8	5	46.0	±28.39		
Third	8.1 - 72	1	58.0			

D. Methods Used to Rewarm

The four different methods that were used by the individual soldiers or battalion surgeons to rewarm frostbitten parts were: walking, exposure to an open fire, massage and exposure to a room temperature environment (70°-78°F.). The majority of cases were rewarmed by one of the first three methods prior to being seen by the battalion surgeon (Table 12). Of the three methods used by the individual soldiers to accomplish rewarming, walking was considered to be the most traumatic to the pre-hyperemic cold injured lower extremity. Cases of frostbite of the feet rewarmed by massage or exposure to an open fire usually did not give a history of trauma by walking

TABLE 12

METHODS OF REWARMING EMPLOYED BY 561 CASES OF FROSTBITE OF THE FEET ACCORDING TO DEGREE OF INJURY

Methods of Rewarming Used	Degree of Injury									
	First		Second		Third		Fourth		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%
Walking	52	21.7	36	21.1	36	29.0	5	19.2	129	23.0
Open Fire	57	23.7	39	22.8	32	25.8	2	7.7	130	23.2
Massage	60	25.0	42	24.6	34	27.4	3	11.5	139	24.8
Room Temperature Exposure (70°-78° F.)	62	25.8	53	31.0	22	17.7	16	61.5	153	27.3
Hot Water Soaks	6	2.5	1	0.6	0	0	0	0	7	1.2
Snow	2	0.8	0	0	0	0	0	0	2	0.4
Cold Water Soaks	1	0.4	0	0	0	0	0	0	1	0.2
Total	240	99.9	171	100.0	124	99.9	26	99.9	561	100.0

to the pre-hyperemic lower extremity. Rewarming of lower extremities by means of room temperature exposure of 70° to 78° F. usually took place in the platoon warm-up bunkers or the battalion aid station. The majority of patients with lower extremity involvement who were rewarmed by this method were transported to a room temperature environment on a litter which obviated the traumatic factor of walking. The cases with frostbite of the hands utilized either exposure to open fire, massage or a room temperature exposure to bring about rewarming (Table 13). The placing of the hands underneath the parka next to the body was considered equivalent to a room temperature exposure and was so

TABLE 13

METHODS OF REWARMING EMPLOYED BY 99 CASES OF FROSTBITE OF THE HANDS ACCORDING TO DEGREE OF INJURY

Methods of Rewarming Used	Degree of Injury									
	First		Second		Third		Fourth		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%
Walking	0	0	0	0	0	0	0	0	0	0
Open Fire	8	27.6	16	27.1	1	14.3	0	0	25	25.3
Massage	11	37.9	13	22.0	1	14.3	1	25.0	26	26.3
Room Temperature Exposure (70°–78° F.)	8	27.6	23	39.0	4	57.1	3	75.0	38	38.4
Hot Water Soaks	2	6.9	5	8.5	0	0	0	0	7	7.1
Snow	0	0	0	0	1	14.3	0	0	1	1.0
Cold Water Soaks	0	0	2	3.4	0	0	0	0	2	2.0
Total	29	100.0	59	100.0	7	100.0	4	100.0	99	100.1

designated. Shortly after completion of rewarming the patient usually noted one or more of the following signs or symptoms: burning, stinging aching pain, paresthesias, edema, hyperemia or vesicle formation.

Table 14 shows comparisons of the mean drying times of vesicles for 215 cases of second and third degree frostbite according to the method that was used to rewarm the cold injured part. The mean drying times of second degree vesicles were not significantly altered by any single method of rewarming. The means ranged from 11.5 to 13.4 days. Those third degree cases rewarmed by a room temperature exposure required a mean of 13.0 days to complete the drying of their vesicles. This mean was

TABLE 14

COMPARISON OF MEAN DRYING TIME OF VESICLES FOR 215 CASES OF FROSTBITE WITH RESPECT TO DEGREE OF INJURY AND METHODS USED TO REWARM

Degree of Injury	Methods of Rewarming	No. of Cases	Mean Drying Time (Days)	Standard Deviation	t	P
Second	All	142	12.7	± 6.55	5.221	<.001
Third	All	73	19.2	± 9.62		
Second	Walking	20	11.5	± 4.98	0.636	>.40
Second	Open Fire	40	12.5	± 7.02		
Second	Walking	20	11.5	± 4.98	1.292	>.10
Second	Room Temp. Exp.	45	13.4	± 6.61		
Second	Walking	20	11.5	± 4.98	0.899	>.30
Second	Massage	37	12.7	± 6.68		
Second	Open Fire	40	12.5	± 7.02	0.626	>.50
Second	Room Temp. Exp.	45	13.4	± 6.61		
Second	Open Fire	40	12.5	± 7.02	0.179	>.80
Second	Massage	37	12.7	± 6.68		
Second	Room Temp. Exp.	45	13.4	± 6.61	0.440	>.60
Second	Massage	37	12.7	± 6.68		
Third	Walking	18	19.7	± 8.20	0.962	>.30
Third	Open Fire	21	22.6	±10.61		
Third	Walking	18	19.7	± 8.20	1.715	>.05
Third	Room Temp. Exp.	8	13.0	± 9.60		
Third	Walking	18	19.7	± 8.20	0.640	>.50
Third	Massage	26	18.0	± 8.75		
Third	Room Temp. Exp.	8	13.0	± 9.60	2.340	<.05
Third	Open Fire	21	22.6	±10.61		
Third	Room Temp. Exp.	8	13.0	± 9.60	1.324	>.10
Third	Massage	26	18.0	± 8.76		
Third	Open Fire	21	22.6	±10.61	1.589	>.10
Third	Massage	26	18.0	± 8.76		
Third	Room Temp. Exp.	8	13.0	± 9.60	0.434	>.60
Second	Walking	20	11.5	± 4.98		
Third	Room Temp. Exp.	8	13.0	± 9.60	0.107	>.90
Second	Room Temp. Exp.	45	13.4	± 6.61		
Third	Room Temp. Exp.	8	13.0	± 9.60	0.154	>.80
Second	Open Fire	40	12.5	± 7.02		
Third	Room Temp. Exp.	8	13.0	± 9.60	0.076	>.90
Second	Massage	37	12.7	± 6.68		

lower than the means obtained for the patients who were rewarmed by either walking, open fire exposure or massage. However, only in the comparison between the vesicular drying times of the room temperature exposure and open fire exposure groups was there a significant difference. Comparisons were also made between the mean drying time of vesicles of third degree lesions of the room temperature exposure group and all those of second degree rewarming groups. These comparisons show that the vesicular drying time in third degree lesions rewarmed at a room temperature exposure were not significantly different from the mean drying time of the second degree lesions regardless of the type of rewarming. Therefore, on the basis of the vesicular drying time in third degree frostbite, the best method of rewarming was a room temperature exposure of 70° to 78°F. and the poorest was exposure to an open fire.

The mean healing times for 212 cases of frostbite of the feet were determined in accordance with the method of rewarming that was used by each patient. The mean healing time, regardless of degree of injury, for each of the following rewarming groups was: walking 43.9 days, open fire exposure 35.8 days, massage 35.7 days and room temperature exposure 28.1 days. The room temperature exposure group took a

significantly shorter period of time to heal than did any other group (Table 15). The healing time of first degree frostbite of the feet when categorized according to methods used to rewarm after injury ranged from 15.4 to 35.0 days. Comparisons of the four rewarming groups in first degree frostbite showed no statistically significant differences in the mean healing times. Similar comparisons of the healing time of second degree lesions of the feet with respect to the method employed to rewarm the injured part showed no significant differences. The ranges of the means in second degree were 22.9 to 26.8 days.

Eighty-six patients with third degree frostbite of the feet when grouped according to the type of rewarming used had the following mean healing times: walking 61.2 days, massage 53.9 days, open fire exposure 49.7 days and room temperature exposure 38.4 days. The mean healing time for third degree frostbite of the feet when rewarmed by room temperature exposure was significantly shorter than the time needed for feet with a like degree of injury when other methods such as walking, exposure to an open fire or massage were used. The mean healing time for third degree frostbite of the feet rewarmed by exposure to an open fire was significantly shorter (11.5 days less) than the time required by those cases who attained rewarming by

TABLE 15

COMPARISON OF MEAN HEALING TIMES OF 212 CASES OF FROSTBITE OF THE FEET WITH RESPECT TO DEGREE OF INJURY AND METHODS USED TO REWARM THE INJURED PART

Degree of Injury	Method Used to Rewarm	No. of Cases	Mean Healing Time (Days)	Standard Deviation	t	P
First	All Methods Combined	25	20.7	±14.67	1.508	>.1
Second	" " "	101	25.5	±10.38		
First	" " "	25	20.7	±14.67	8.661	<.001
Third	" " "	85	52.3	±19.95		
Second	" " "	101	25.5	±10.38	11.241	<.001
Third	" " "	85	52.3	±19.95		
Combined	Walking	52	43.9	±24.08	1.902	>.05
"	Open Fire	53	35.[illegible]	±19.43		
"	Walking	52	43.9	±24.08	4.217	<.001
"	Room Temperature	55	28.[illegible]	±12.64		
"	Walking	52	43.9	±24.08	1.831	>.05
"	Massage	52	35.7	±21.58		
"	Open Fire	53	35.[illegible]	±19.43	2.425	<.02
"	Room Temperature	55	28.[illegible]	±12.64		
"	Open Fire	53	35.[illegible]	±19.43	0.020	>.90
"	Massage	52	35.7	±21.58		
"	Room Temperature	55	[illegible]	±12.64	2.206	<.05
"	Massage	52	35.7	±21.58		
First	Walking	5	[illegible]	±25.61	1.285	>.20
"	Open Fire	7	17.[illegible]	±10.47		
"	Walking	5	35.[illegible]	±25.61	1.650	>.20
"	Room Temperature	8	15.[illegible]	± 9.09		
"	Walking	5	35.[illegible]	±25.61	1.201	>.20
"	Massage	5	19.[illegible]	±12.03		
"	Open Fire	7	17.[illegible]	±10.47	0.402	>.60
"	Room Temperature	8	15.[illegible]	± 9.09		
"	Open Fire	5	17.[illegible]	±10.47	0.355	>.70
"	Massage	5	19.[illegible]	±12.03		
"	Room Temperature	8	15.[illegible]	± 9.09	0.706	>.40
"	Massage	5	19.[illegible]	±12.03		
Second	Walking	22	[illegible]	±12.18	0.273	>.70
"	Open Fire	21	25.[illegible]	±11.32		
"	Walking	22	[illegible]	±12.18	0.149	>.80
"	Room Temperature	33	[illegible]	± 9.66		
"	Walking	22	[illegible]	±12.18	1.076	>.20
"	Massage	25	[illegible]	± 9.63		
"	Open Fire	21	25.[illegible]	±11.32	0.482	>.60
"	Room Temperature	33	[illegible]	± 9.66		

TABLE 15 (con't)

COMPARISON OF MEAN HEALING TIMES OF 212 CASES OF FROSTBITE OF THE FEET WITH RESPECT TO DEGREE OF INJURY AND METHODS USED TO REWARM THE INJURED PART

Degree of Injury	Method Used to Rewarm	No. of Cases	Mean Healing Time (Days)	Standard Deviation	t	P
Second	Open Fire	21	25.4	±11.32	0.798	>.40
"	Massage	25	22.9	± 9.63		
"	Room Temperature	33	26.8	± 9.66	1.541	>.10
"	Massage	25	22.9	± 9.63		
Third	Walking	25	61.2	±21.31	2.053	<.05
"	Open Fire	25	49.7	±18.10		
"	Walking	25	61.2	±21.31	4.009	<.001
"	Room Temperature	14	38.4	±13.99		
"	Walking	25	61.2	±21.31	1.169	>.05
"	Massage	22	53.9	±21.14		
"	Open Fire	25	49.7	±18.10	2.161	<.05
"	Room Temperature	14	38.4	±13.99		
"	Open Fire	25	49.7	±18.10	0.732	>.40
"	Massage	22	53.9	±21.14		
"	Room Temperature	14	33.4	±13.99	2.643	<.02
"	Massage	22	53.9	±21.14		

walking. The group of patients rewarmed by massage had a healing time which was not significantly different from third degree lesions rewarmed by walking. It appears that the best method of rewarming, as far as healing of third degree frostbite of the feet is concerned, was exposure to a room temperature (70° to 78° F.), the next best method was exposure to an open fire and the poorest was by walking.

The mean healing time for 42 cases of second degree frostbite of the hands, with respect to the method of rewarming used by patients, ranged from 19.2 to 23.4

days (Table 16). The largest mean was among those patients

TABLE 16

COMPARISON OF MEAN HEALING TIMES OF 47 CASES OF FROSTBITE OF THE HANDS WITH RESPECT TO DEGREE OF INJURY AND METHODS USED TO REWARM THE INVOLVED PART

Degree of Injury	Method Used to Rewarm	No. of Cases	Mean Healing Time (Days)	Standard Deviation	t	P
Second Third	Combined "	42 5	21.7 49.0	± 8.04 ±28.89	2.106	<.05
Combined "	Open Fire Room Temperature	13 24	19.2 27.96	± 6.75 ±16.83	2.226	<.05
" "	Open Fire Massage	13 10	19.2 23.4	± 6.75 ±12.54	0.951	>.30
" "	Room Temperature Massage	24 10	27.96 23.4	±16.83 ±12.54	0.868	>.30
Second "	Open Fire Room Temperature	13 20	19.2 23.4	± 6.75 ± 7.96	1.595	>.10
" "	Open Fire Massage	13 9	19.2 21.4	± 6.75 ±11.44	0.520	>.60
" "	Room Temperature Massage	20 9	23.4 21.4	± 7.96 ±11.44	0.454	>.60
Third "	Room Temperature Massage	4 1	51.0 41.0	±33.93		

who had rewarmed by a room temperature exposure. The lowest mean of 19.2 days was attained by the open fire exposure group. Comparisons of these means show them not to be significantly different. The healing of second degree frostbite of the hands was not influenced by the method used to rewarm the cold injury.

There were only five cases of third degree frostbite of the hands who had healing times recorded with respect to the method used to rewarm the involved part. No

conclusions could be made regarding the efficacy of rewarming methods for this degree of injury.

E. Delay in Evacuation and Medical Care

The rate of wound healing is partially dependent upon the presence or absence of trauma after the injury has been sustained. Continuation of trauma to an injury may retard the process of healing. In some wounds the healing rate also may be dependent upon the time proper medical care is instituted.

In frostbite injuries the factor of trauma cannot be eliminated as long as the soldier remains on duty. This trauma usually results from walking or continuation of exposure of the injured tissues to low ambient temperatures, but not of a low enough degree to produce further cold injury to the already damaged tissues. For these reasons the present military directives on cold injuries state that early evacuation of the frostbite casualty to a medical installation is mandatory. It is conceivable that there may be times when the success or failure of a combat mission will depend upon whether or not unit commanders comply with such a directive. If continuation of trauma to a cold injury does not increase the degree of severity of the wound or retard its healing then a delay in evacuation in order to conserve manpower and firepower and complete a successful mission may be justified.

The effect of continued trauma to frostbite injuries was determined by evaluating the vesicular drying time and rate of wound healing with respect to the time that the casualty was evacuated from his unit to a medical installation. Delay in evacuation from the combat unit was defined as the number of hours that elapsed between the accomplishment of rewarming and the arrival of the patient at the battalion aid station for medical care. The delay in evacuation or the duration of trauma after injury for 662 frostbite casualties ranged from 0 to 504 hours. The mean delay for the entire group was 102 hours. A value of zero was applicable to those cases of frostbite who were rewarmed in the battalion aid station and then evacuated to a larger medical installation via litter.

During the winter of 1950-51 it was uncommon for the frostbite casualty to be seen by medical personnel (or evacuated from his unit) prior to rewarming. Only 2.1% of 1,368 frostbite cases were rewarmed in a medical installation. This same situation existed during the winter of 1951-52 in that only 4.2% of 662 cases were rewarmed in a medical installation. The percentage distribution of 562 cases of frostbite of the feet and 100 cases of frostbite of the hands with respect to time of medical care and evacuation after injury is shown in Tables 17 and 18.

It is reasonable to assume that a frostbite casualty

TABLE 17

TIME AFTER REWARMING BY DEGREE OF INJURY THAT 562 CASES OF FROSTBITE OF THE FEET REPORTED FOR MEDICAL CARE AND EVACUATION

Time After Injury For Medical Care and Evacuation	Degree of Injury									
	First		Second		Third		Fourth		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%
Before Rewarming	10	4.1	1	0.6	7	5.6	7	26.9	25	4.4
1-24 Hrs. After Rewarming	121	50.0	73	42.9	49	39.5	13	50.0	256	45.6
25-48 Hrs. After Rewarming	41	16.9	26	15.3	21	16.9	2	7.7	90	16.0
49-72 Hrs. After Rewarming	10	4.1	15	8.8	4	3.2	1	3.8	30	5.3
73-96 Hrs. After Rewarming	15	6.2	7	4.1	9	7.3	1	3.8	32	5.7
97-120 Hrs. After Rewarming	12	5.0	8	4.7	4	3.2	0	0	24	4.3
121-144 Hrs. After Rewarming	5	2.1	6	3.5	3	2.4	1	3.8	15	2.7
7-14 Days After Rewarming	15	6.2	22	12.9	12	9.7	1	3.8	50	8.9
14-21 Days After Rewarming	13	5.4	12	7.1	15	12.1	0	0	40	7.1
Total	242	100.0	170	100.0	124	100.0	26	100.0	562	100.0

should be evacuated from combat within 24 hours after injury. For this reason the cases were divided into two groups (0-24 hrs. and 24.1 to 504 hrs.) so as to elicit differences in the drying and healing times of frostbite lesions in relation to delay in evacuation and medical care.

In second degree frostbite the cases who were evacuated within 24 hours after injury had a mean vesicle drying time of 11.3 days while patients evacuated more than 24 hours

TABLE 18

TIME AFTER REWARMING BY DEGREE OF INJURY THAT 100 CASES OF FROSTBITE OF THE HANDS REPORTED FOR MEDICAL CARE AND EVACUATION

Time After Injury For Medical Care and Evacuation	Degree of Injury									
	First		Second		Third		Fourth		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%
Before Rewarming	1	3.4	1	1.7	0	0	1	25.0	3	3.0
1-24 Hrs. After Rewarming	12	41.4	33	55.9	7	87.5	3	75.0	55	55.0
25-48 Hrs. After Rewarming	2	6.9	4	6.8	0	0	0	0	6	6.0
49-72 Hrs. After Rewarming	4	13.8	3	5.1	0	0	0	0	7	7.0
73-96 Hrs. After Rewarming	2	6.9	5	8.5	0	0	0	0	7	7.0
97-120 Hrs. After Rewarming	1	3.4	1	1.7	0	0	0	0	2	2.0
121-144 Hrs. After Rewarming	1	3.4	4	6.8	1	12.5	0	0	6	6.0
7-14 Days After Rewarming	3	10.4	5	8.5	0	0	0	0	8	8.0
14-21 Days After Rewarming	3	10.4	3	5.1	0	0	0	0	6	6.0
Total	29	100.0	59	100.0	8	100.0	4	100.0	100	100.0

after injury had a mean of 13.6 days. Comparison between these means showed that a delay of more than 24 hours in evacuation resulted in a statistically significant increase of 2 days in the vesicular drying time (Table 19). The mean vesicular drying time for patients with third degree frostbite who were evacuated within 24 hours after injury was 17.3 days while cases of like degree who were evacuated more than 24 hours after injury had a mean of 20.1 days. There was no significant difference between the above means.

TABLE 19

COMPARISONS OF MEAN DRYING TIME OF VESICLES FOR 223 CASES OF FROSTBITE WITH RESPECT TO DEGREE OF SEVERITY AND TIME AFTER INJURY THAT EVACUATION AND MEDICAL CARE WAS INSTITUTED

Degree of Injury	Hours After Injury for Medical Care	No. of Cases	Mean Drying Time (Days)	Standard Deviation	t	P
Second Third	0 to 504 0 to 504	147 76	12.7 19.0	± 6.57 ± 9.59	5.088	<.001
Second Second	0 to 24 24.1 to 504	57 90	11.3 13.6	± 6.64 ± 6.23	2.014	<.05
Third Third	0 to 24 24.1 to 504	31 45	17.3 20.1	± 8.50 ±10.12	1.338	>.10
Second Third	0 to 24 0 to 24	57 31	11.3 17.3	± 6.84 ± 8.50	3.342	<.01
Second Third	0 to 24 24.1 to 504	57 45	11.3 20.1	± 6.84 ±10.12	5.565	<.001
Second Third	24.1 to 504 0 to 24	90 31	13.6 17.3	± 6.23 ± 8.50	2.209	<.05
Second Third	24.1 to 504 24.1 to 504	90 45	13.6 20.1	± 6.23 ±10.12	3.964	<.001

Therefore only the drying time of second degree vesicles was altered by a continuation of trauma after injury.

The mean healing time for 14 cases of first degree frostbite of the feet who were evacuated within 24 hours after injury was 14 days, while the mean for 14 patients of like degree and site evacuated more than 24 hours after injury was 27.2 days (Table 20). The delay in evacuation and medical care beyond 24 hours resulted in a significant prolongation of healing by 13 days. This represented an increase of 182 days hospitalization for only 14 cases of first degree frostbite of the feet. In second degree frostbite of the feet there were 40 patients evacuated

TABLE 20

COMPARISON OF MEAN HEALING TIMES OF 217 CASES OF FROSTBITE OF THE FEET WITH RESPECT TO DEGREE OF SEVERITY AND TIME AFTER INJURY THAT MEDICAL CARE AND EVACUATION WERE INSTITUTED

Degree of Injury	Hours after Injury Medical Care and Evacuation Instituted	No. of Cases	Mean Healing Time (Days)	Standard Deviation	t	P
First	0 to 504	28	20.6	±14.60	1.501	>.10
Second	0 to 504	101	25.0	±10.33		
First	0 to 504	28	20.6	±14.60	9.213	<.001
Third	0 to 504	88	52.9	±20.35		
Second	0 to 504	101	25.0	±10.33	11.629	<.001
Third	0 to 504	88	52.9	±20.35		
Combined	0 to 24	89	32.6	±20.54	1.896	>.05
"	24.1 to 504	128	38.0	±21.23		
First	0 to 24	14	14.0	± 9.96	2.611	<.02
"	24.1 to 504	14	27.2	±16.10		
Second	0 to 24	40	23.6	± 9.52	1.176	>.20
"	24.1 to 504	61	26.0	±10.72		
Third	0 to 24	35	50.3	±19.80	1.020	>.30
"	24.1 to 504	53	54.7	±20.51		
First	0 to 24	14	14.0	± 9.96	3.133	<.01
Second	0 to 24	40	23.6	± 9.52		
First	0 to 24	14	14.0	± 9.96	3.999	<.001
Second	24.1 to 504	61	26.0	±10.72		
First	0 to 24	14	14.0	± 9.96	8.480	<.001
Third	0 to 24	35	50.3	±19.80		
First	0 to 24	14	14.0	± 9.96	10.505	<.001
Third	24.1 to 504	53	54.7	±20.51		
First	24.1 to 504	14	27.2	±16.10	0.796	>.40
Second	0 to 24	40	23.6	± 9.52		
First	24.1 to 504	14	27.2	±16.10	0.272	>.70
Second	24.1 to 504	61	26.0	±10.72		
First	24.1 to 504	14	27.2	±16.10	4.229	<.001
Third	0 to 24	35	50.3	±19.80		
First	24.1 to 504	14	27.2	±16.10	5.349	<.001
Third	24.1 to 504	53	54.7	±20.51		
Second	0 to 24	40	23.6	± 9.52	7.272	<.001
Third	0 to 24	35	50.3	±19.80		
Second	0 to 24	40	23.6	± 9.52	9.751	<.001
Third	24.1 to 504	53	54.7	±20.51		
Second	24.1 to 504	61	26.0	±10.72	6.713	<.001
Third	0 to 24	35	50.3	±19.80		
Second	24.1 to 504	61	26.0	±10.72	9.171	<.001
Third	24.1 to 504	53	54.7	±20.51		

within 24 hours after injury whose mean healing time was 23.6 days, while 61 cases who were evacuated beyond 24 hours had a mean of 26 days. This mean increase of 2.4 days proved not to be significant. In third degree frostbite of the feet the delay in evacuation beyond 24 hours prolonged the healing 4.4 mean days which also was not significant. Delay in evacuation or continuation of trauma for more than 24 hours after injury retarded the healing of first degree frostbite of the feet. It would appear that trauma affected the healing of superficial layers of the skin, but apparently it exerted no deleterious effect on the healing of underlying tissues when overlying full or partial layers of epidermis had been destroyed by cold. Skin destroyed by cold appeared to form a protective barrier for underlying tissues.

A comparison of the mean healing times for 58 cases of frostbite of the hands with respect to time of evacuation is shown in Table 21. There was no statistically significant prolongation of healing of first and second degree hand lesions as the result of delay in evacuation. This lack of difference in healing of hands may be accounted for by the greater circulation in upper extremities as compared to lower extremities and by the ease with which the patient was able to protect his hands against trauma.

F. Bootgear Worn at Time of Injury

Three types of boots were worn by the United States troops

TABLE 21

COMPARISON OF MEAN HEALING TIMES FOR 58 CASES OF FROSTBITE OF THE HANDS WITH RESPECT TO DEGREE OF SEVERITY AND TIME AFTER INJURY THAT MEDICAL CARE AND EVACUATION WERE INSTITUTED

Degree of Injury	Hours after Injury Medical Care and Evacuation Instituted	No. of Cases	Mean Healing Time (Days)	Standard Deviation	t	P
First Second	0 to 504 0 to 504	4 48	22.8 21.83	±11.13 ± 8.08	0.162	>.90
First Third	0 to 504 0 to 504	4 6	22.8 48.0	±11.13 ±25.46	2.142	>.05
Second Third	0 to 504 0 to 504	48 6	21.83 48.0	± 8.08 ±25.46	2.503	<.02
Combined "	0 to 24 24.1 to 504	36 22	25.1 23.9	±14.79 ± 9.69	0.373	>.70
First "	0 to 24 24.1 to 504	3 1	19.7 32.0	±11.11 - -		
Second "	0 to 24 24.1 to 504	27 21	20.56 23.48	± 6.98 ± 9.76	1.160	>.20

during the winter of 1951-52. With the onset of cold weather in November 1951 the troops changed from leather boots to shoepacs. In December the infantry regiments began substituting a new insulated rubber boot for shoepacs. Frostbite occurred among soldiers wearing all three types of boots, although the incidence of frostbite was lowest for those troops equipped with the insulated boot. Through interviews concerning the bootgear worn by the frostbite casualty at time of injury, it was found that 20.8% of the patients were wearing sockgear that either caused a constriction of the feet or did not provide adequate insulation (Table 22). Constriction of the feet

TABLE 22

CONSTRICTIVE AND INADEQUATE INSULATIVE COMBINATIONS OF SOCKGEAR WORN BY 558 CASES OF FROSTBITE OF THE FEET AT TIME OF INJURY WITH RESPECT TO RACE

Combinations of Sockgear	White		Negro		Total	
	No.	%	No.	%	No.	%
Constrictive Combination	45	13.6	23	10.2	68	12.2
Inadequate Insulation	27	8.1	21	9.3	48	8.6
Adequate Insulation without Constriction	260	78.3	182	80.5	442	79.2
Total	332	100.0	226	100.0	558	100.0

was usually produced by wearing too many socks in an attempt to obtain greater insulation against the cold. The majority of constrictive combinations occurred among soldiers wearing the leather combat boot (Table 23). Inadequate insulation of the feet occurred when soldiers equipped with shoepacs wore less than the prescribed number of socks, or they failed to use the insole that is a necessary item for this type of bootgear.

The mean times for drying of vesicles and healing of frostbite wounds of the feet were evaluated with respect to the type of boot worn at time of injury regardless of the constrictive or inadequate insulative factors. The mean time required to dry second degree vesicles of patients who wore leather combat boots was 16.6 days, while cases with like degree of injury wearing shoepacs had a mean of 11 days.

TABLE 23

CONSTRICTIVE AND INADEQUATE INSULATIVE COMBINATIONS OF SOCKGEAR FOR TYPE OF BOOTGEAR WORN AT TIME OF INJURY BY 558 CASES OF FROSTBITE OF THE FEET WITH RESPECT TO RACE

Type of Shoegear	Constrictive Combinations				Inadequate Insulation				Correct Combinations				Total	
	White		Negro		White		Negro		White		Negro			
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Leather Boots	43	95.6	21	91.3	0	0	1	4.8	96	36.9	82	45.1	243	43.5
Shoepac	1	2.2	1	4.3	27	100.0	20	95.2	157	60.4	93	51.1	299	53.6
Insulated Rubber Boots	1	2.2	1	4.3	0	0	0	0	7	2.7	7	3.8	16	2.9
Total	45	100.0	23	99.9	27	100.0	21	100.0	260	100.0	182	100.0	558	100.0

Comparisons of these two means showed that shoepacs produced a significant reduction of 5.6 days in the drying time (Table 24). In third degree there were 35 cases

TABLE 24

COMPARISON OF MEAN DRYING TIME OF VESICLES FOR 162 CASES OF FROSTBITE OF THE FEET WITH RESPECT TO DEGREE OF SEVERITY AND TYPE OF BOOTS WORN AT TIME OF INJURY

Degree of Injury	Type of Boots	No. of Cases	Mean Drying Time (Days)	Standard Deviation	t	P
Second Second	Leather Boots Shoepacs	29 69	16.6 11.0	±7.20 ±5.83	3.719	<.01
Third Third	Leather Boots Shoepacs	35 29	22.8 16.3	±9.15 ±9.33	2.781	<.01
Second Third	Leather Boots Leather Boots	29 35	16.6 22.8	±7.20 ±9.15	3.022	<.01
Second Third	Leather Boots Shoepacs	29 29	16.6 16.3	±7.20 ±9.33	0.129	>.80
Second Third	Shoepacs Leather Boots	69 35	11.0 22.8	±5.83 ±9.15	6.945	<.001
Second Third	Shoepacs Shoepacs	69 29	11.0 16.3	±5.83 ±9.33	2.856	<.01

wearing shoepacs who had a mean drying time of 16.3 days while in 29 patients equipped with leather boots the mean was 22.8 days. This reduction of mean drying time by 6.5 days for the shoepac group was significant. The drying time for the 29 cases of second degree wearing leather boots was not significantly different from the vesicular drying time attained by 29 cases of third degree wearing shoepacs. The vesicular drying time for frostbite of the feet was dependent upon the type of bootgear

worn at time of injury.

Irrespective of degree of injury 254 cases of frostbite of the feet with respect to bootgear had the following mean healing times: leather boots 44.2 days, shoepacs 31.4 days and insulated boots 21 days. One reason for these marked differences was that the more severe frostbite lesions occurred among soldiers wearing the leather boots. In first degree frostbite of the feet only the insulated boot cases showed a significant reduction in healing time as compared to shoepacs (Table 25). The mean healing time of second degree frostbite for patients wearing leather combat boots was 31.4 days and for soldiers in shoepacs, 23 days. The factor of wearing shoepacs significantly reduced the healing time of second degree frostbite by 8.4 days. In the comparison of insulated boots with shoepacs there was no significant difference in the healing rate of second degree lesions. The reason for this lack of difference is not known but may be due to an insufficient number of cases in the insulated boot group. The longest mean healing time in third degree injuries (59 days) occurred in a group of patients wearing leather combat boots, while cases who wore the shoepacs took 50.4 days to heal lesions of like degree. The shortest mean healing time for third degree frostbite of the feet was attained in three cases who had worn the insulated boots. Comparisons between the above three mean healing

TABLE 25

COMPARISONS OF MEAN HEALING TIMES FOR 254 CASES OF FROSTBITE OF THE FEET WITH RESPECT TO DEGREE OF INJURY AND THE TYPE OF BOOTS WORN

Degree of Injury	Type of Boot Worn	No. of Cases	Mean Healing Time (Days)	Standard Deviation	t	P
First Second	All Types " "	41 116	21.2 25.0	±14.32 ±10.23	1.58	>.10
First Third	All Types " "	41 97	21.2 53.6	±14.32 ±21.41	10.394	<.001
Second Third	All Types " "	116 97	25.0 53.6	±10.23 ±21.41	12.049	<.001
All Degrees " "	Insulated Boots Leather Boots	9 84	21.0 44.2	± 8.16 ±24.70	6.061	<.001
All Degrees " "	Insulated Boots Shoepacs	9 161	21.0 31.4	± 8.16 ±18.50	3.378	<.01
All Degrees " "	Leather Boots Shoepacs	84 161	44.2 31.4	±24.70 ±18.50	4.184	<.001
First "	Insulated Boots Leather Boots	4 14	14.5 23.1	± 2.69 ±16.64	1.854	>.05
First "	Insulated Boots Shoepacs	4 23	14.5 21.1	± 2.69 ±13.64	2.101	<.05
First "	Leather Boots Shoepacs	14 23	23.1 21.1	±16.64 ±13.64	0.379	>.70
Second "	Insulated Boots Leather Boots	2 27	24.0 31.4	± 5.00 ± 9.96	1.8[illegible]	>.05
Second "	Insulated Boots Shoepacs	2 87	24.0 23.0	± 5.00 ± 9.57	0.272	>.70
Second "	Leather Boots Shoepacs	27 87	31.4 23.0	± 9.96 ± 9.57	3.865	<.001
Third "	Insulated Boots Leather Boots	3 43	27.7 59.2	± 8.18 ±23.82	5.293	<.001
Third "	Insulated Boots Shoepacs	3 51	27.7 50.4	± 8.18 ±17.71	4.261	<.001
Third "	Leather Boots Shoepacs	43 51	59.2 50.4	±23.82 ±17.71	2.001	<.05

times indicated that area involvement by third degree frostbite was greater in leather boots than it was in shoepacs or insulated boots. The period of wound healing of frostbite injuries of the feet was dependent upon the

type of bootgear worn at the time of the cold exposure. If the 84 cases of frostbite of the feet had worn shoepacs instead of leather boots at time of injury there would have been a saving of 1,075 days in the mean wound healing time.

G. Handgear Worn at Time of Injury

The front-line troops were equipped with two types of handgear, namely, mittens or gloves. A complete ensemble of mittens or gloves consisted of two parts, an outer leather shell and a woolen insert. The cases of frostbite of the hands were classified as to whether there was adequate or inadequate insulation of the hands at the time of injury. Cases that were classed as having adequate insulation wore a complete ensemble of either gloves or mittens. Those that were considered to have had inadequate insulation were wearing either the outer leather shell or the woolen insert or were barehanded. Among 177 patients with frostbite of the hands 27.7% had inadequate insulation at the time of injury (Table 26). There was no marked percentage difference between the White and Negro soldiers.

The mean drying time of second degree vesicles for 33 patients with respect to type of handgear worn ranged from 10.6 to 15.1 days. The type of handgear worn at the time of injury did not produce a significant alteration in the drying time of second degree vesicles (Table 27). Likewise, comparisons of the mean healing times between cases of second and third degree frostbite of the hands according

TABLE 26

DISTRIBUTION OF 177 CASES OF FROSTBITE OF THE HANDS WITH RESPECT TO RACE AND TYPE OF HANDGEAR WORN

Handgear	White		Negro		Total	
	No.	%	No.	%	No.	%
Complete gloves or mittens (Adequate insulation)	73	70.2	55	75.3	128	72.3
Incomplete combinations (Inadequate insulation)	31	29.8	18	24.7	49	27.7
Total	104	100.0	73	100.0	177	100.0

TABLE 27

COMPARISON OF MEAN DRYING TIME FOR VESICLES OF 33 CASES OF SECOND DEGREE FROSTBITE OF THE HANDS WITH RESPECT TO TYPE OF HANDGEAR WORN AT TIME OF INJURY

Type of Handgear	No. of Cases	Mean Drying Time (Days)	Standard Deviation	t	P
Complete Mittens Complete Glove	7 14	10.6 14.5	±4.18 ±6.90	1.618	>.10
Complete Mittens Partial Combinations	7 12	10.6 15.1	±4.18 ±7.92	1.623	>.10
Complete Glove Partial Combinations	14 12	14.5 15.1	±6.90 ±7.92	0.197	>.80
Gloves and Mittens Partial Combinations	21 12	13.0 15.1	±6.65 ±7.92	0.768	>.40

to the type of handgear worn at the time of injury failed to show significant differences (Table 28).

H. Condition of Extremity at Time of Injury

The rate of loss of body heat from an extremity during a cold exposure may be accelerated when the

TABLE 28

COMPARISONS OF MEAN HEALING TIME FOR 55 CASES OF FROSTBITE OF THE HANDS WITH RESPECT TO DEGREE OF INJURY AND TYPE OF HANDGEAR WORN

Degree of Injury	Type of Handgear	No. of Cases	Mean Days For Healing	Standard Deviation	t	P
Second Third	All Types " "	49 6	21.7 48.0	± 8.07 ±25.92	2.473	<.02
Combined "	Mittens Gloves	13 21	20.0 28.6	±10.01 ±18.38	1.745	>.10
Combined "	Mittens Inadequate Combinations*	13 21	20.0 23.4	±10.01 ± 8.90	1.014	>.20
" "	Gloves Inadequate Combinations	21 21	28.6 23.4	±18.38 ± 8.90	1.137	>.20
Second "	Mittens Gloves	13 17	20.0 22.8	±10.01 ± 8.17	0.851	>.40
Second "	Mittens Inadequate Combinations	13 19	20.0 24.8	±10.01 ± 7.73	0.583	>.50
Second "	Gloves Inadequate Combinations	17 19	22.8 21.8	± 8.17 ± 7.73	0.368	>.70
Second Third	Inadequate Combinations Gloves	19 4	21.8 53.0	± 7.73 ±33.21	1.860	>.05

* Inadequate combinations include those cases that were barehanded at time of injury.

foot or hand is wet. Therefore wetness or dryness could be a factor that determines the eventual degree of severity and area involvement of the cold injury, which in turn might well be reflected in the rate of drying of vesicles and healing of the injury. Information based upon interviews yielded data on wet-cold as follows. A foot or hand was considered to be wet when the socks or gloves were

moderately saturated with either sweat or external fluids originating from wading in water, standing or lying on muddy ground or from melted snow.

The percentage distribution of 686 frostbite patients according to the condition of their hands and feet at time of injury is shown in Table 29. The percentage of wet feet

TABLE 29

DISTRIBUTION OF 686 FROSTBITE PATIENTS WITH RESPECT TO CONDITION OF THEIR FEET AND HANDS AT TIME OF COLD INJURY

Condition of Extremity	Hands		Feet	
	No.	%	No.	%
Dry	533	77.7	219	31.9
Wet	153	22.3	467	68.1
Total	686	100.0	686	100.0

was extremely high in spite of such preventive measures as: frequent inspection of feet and footgear, extra issue of socks and insoles to each soldier and a mandatory change of socks and insoles daily. The accumulation of sweat was more pronounced among those soldiers wearing shoepacs or insulated boots. Wetting of feet in leather boots was usually caused by external fluids.

Patients with second degree frostbite whose injured extremities were dry at time of injury had a mean

vesicular drying time of 9.8 days while cases with a wet extremity had a mean of 13.5 days (Table 30). A wet

TABLE 30

COMPARISON OF MEAN DRYING TIME OF VESICLES FOR 225 CASES OF FROSTBITE WITH RESPECT TO DEGREE OF SEVERITY AND CONDITION OF THE INJURED EXTREMITY AT TIME OF INJURY

Degree of Injury	Condition of Extremity at Time of Injury	No. of Cases	Mean Drying Time (Days)	Standard Deviation	t	P
Second "	Dry Wet	46 103	9.8 13.5	± 7.88 ± 7.11	2.867	<.01
Third "	Dry Wet	21 55	20.9 18.5	±10.85 ± 9.19	0.9017	>.40
Second Third	" "	103 55	13.5 18.5	± 7.11 ± 9.19	5.957	<.001
Second Third	" Dry	103 21	13.5 20.9	± 7.11 ±10.85	4.461	<.001
Second Third	" "	46 21	9.8 20.9	± 7.88 ±10.85	2.853	<.01
Second Third	" Wet	46 55	9.8 18.5	± 7.88 ± 9.19	3.063	<.01

extremity caused the drying time of second degree vesicles to be increased by 3.7 days. The mean drying time for third degree vesicles of wet and dry extremities was 18.5 and 20.9 days, respectively, which were not significantly different. A state of wetness or dryness of extremities only influenced the rate of drying of second degree vesicles.

Irrespective of degree of injury frostbite patients whose feet were dry at the time of injury had a mean healing time of 35.1 days while cases with wet feet had a mean of 35.8 days (Table 31). Comparisons of the mean healing times of

TABLE 31

COMPARISON OF MEAN HEALING TIMES FOR 224 CASES OF FROSTBITE OF THE FEET WITH RESPECT TO DEGREE OF SEVERITY AND CONDITION OF FEET AT TIME OF INJURY

Degree of Injury	Condition of Feet	No. of Cases	Mean Healing Time (Days)	Standard Deviation	t	P
First Second	Combined "	27 103	21.2 25.3	±14.54 ±10.37	1.389	>.10
First Third	" "	27 94	21.2 50.9	±14.54 ±22.46	8.174	<.001
Second Third	" "	103 94	25.3 50.9	±10.37 ±22.46	10.093	<.001
Combined "	Dry Wet	67 157	35.1 35.8	±23.16 ±20.55	0.199	>.80
First "	" Dry	20 7	22.6 17.1	±16.30 ± 8.19	1.142	>.20
Second "	Wet Dry	75 28	25.7 24.3	±10.97 ± 8.78	0.709	>.40
Third "	Wet Dry	62 32	52.1 48.5	±20.04 ±26.38	0.674	>.40
First Second	Wet "	20 75	22.6 25.7	±16.30 ±10.97	0.811	>.40
First Second	" Dry	20 28	22.6 24.3	±16.30 ± 8.78	0.412	>.60
First Third	Wet "	20 62	22.6 52.1	±16.30 ±20.04	6.638	<.001
First Third	" Dry	20 32	22.6 48.5	±16.30 ±26.38	4.381	<.001
First Second	" Wet	7 75	17.1 25.7	± 8.19 ±10.97	2.569	<.02
First Second	Dry "	7 28	17.1 24.3	± 8.19 ± 8.78	2.024	<.05
First Third	" Wet	7 62	17.1 52.1	± 8.19 ±20.04	8.727	<.001
First Third	Dry "	7 32	17.1 48.5	± 8.19 ±26.38	5.608	<.001
Second Third	Wet "	75 62	25.7 52.1	±10.97 ±20.04	9.280	<.001
Second Third	" Dry	75 32	25.7 48.5	±10.97 ±26.38	4.718	<.001
Second Third	" Wet	28 62	24.3 52.1	± 8.78 ±20.04	9.169	<.001
Second Third	Dry "	28 32	24.3 48.5	± 8.78 ±26.38	4.905	<.001

wet and dry feet within first, second and third degree frostbite did not show any significant differences. The healing of frostbitten feet did not appear to be influenced by the condition of the lower extremity (wet or dry) at the time of injury. This might mean that the degree of severity and area of involvement in frostbite of the feet was not necessarily predicated upon the rapidity and duration of loss of local body heat during the cold exposure.

In frostbite of the hands irrespective of degree of injury the mean healing time for patients who had dry hands was 24.2 days while men whose hands were wet at the time of injury had a mean of 24.7 days (Table 32). In second degree

TABLE 32

COMPARISON OF MEAN HEALING TIMES FOR 59 CASES OF FROSTBITE OF THE HANDS WITH RESPECT TO DEGREE OF SEVERITY AND CONDITION OF HANDS AT TIME OF INJURY

Degree of Injury	Condition of Hands	No. of Cases	Mean Healing Time (Days)	Standard Deviation	t	P
First Second	Combined "	4 49	22.8 21.7	±11.13 ± 8.07	0.190	>.80
First Third	" "	4 6	22.8 48.0	±11.13 ±25.46	2.142	>.05
Second Third	" "	49 6	21.7 22.8	± 8.07 ±11.13	2.518	<.02
Combined "	Dry Wet	35 24	24.2 24.7	±10.27 ±16.76	0.125	>.90
First First	Dry Wet	2 2	24.5 21.0	± 7.00 ±22.00	0.214	>.80
Second "	Dry Wet	32 17	23.2 18.9	± 8.82 ± 5.76	2.044	<.05
Third "	Dry Wet	1 5	58.0 46.0	± — ±28.39		

frostbite cases with dry hands had a significantly shorter healing time of 4.3 mean days than did patients of like degree with wet hands. The healing times for wet and dry hands within first and third degree frostbite were not significantly different. The extent of involvement in second degree frostbite of the hands may be dependent upon the rate of local cooling of the tissues during the cold exposure.

IV. TREATMENT

The management and treatment of the frostbite patient during the winter of 1951-52 was well standardized throughout all medical installations handling this type of cold injury casualty. In the forward combat area the following measures were instituted by the medical corpsmen and unit surgeons:

1) All constricting items of clothing such as boots, gloves and socks were removed from the site of injury.
2) Cold injured parts were rewarmed by exposure to room temperature (70° - 78° F.) whenever possible.
3) Measures were instituted for restoration of general body warmth.
4) As soon as possible all patients with severe first, second, third and fourth degree frostbite of the feet were made litter patients.
5) Intact vesicles or bullae were not drained or debrided.
6) Large vesicles or bullae were covered with a dry loose dressing to provide protection and maintain warmth.

7) A tetanus toxoid booster and penicillin were administered at the battalion aid station or division clearing station.

All frostbite patients were assembled at the forward mobile surgical hospitals, and then they were evacuated directly to a cold injury treatment center located approximately 200 miles behind the front lines. The routine management and treatment of frostbite in the specialized center was as follows:

1) Absolute bed rest was mandatory only for those patients with frostbite of the feet. Bed rest was maintained in severe first and second degree frostbite until subsidence of edema and/or complete drying of vesicles or bullae had taken place. Third degree patients remained at bed rest until all their ulcerations were re-epithelialized. Cases with fourth degree frostbite of the feet were not allowed to be ambulatory until surgery had been performed and all wounds were healed.
2) The rule of "no smoking" was enforced in order to avoid the vasoconstrictive effects of nicotine.
3) Active physiotherapy was instituted at the bedside immediately after admission to the cold injury center. Attention was directed toward positioning of the feet and the movement of fingers and toes and other major joints. Patients with frostbite of the hands were usually most reluctant to initiate and maintain

active movement of injured fingers which is necessary if anklyosis of the interdigital joints is to be avoided. The importance of active physiotherapy by the patient during the first 6 weeks post-frostbite period cannot be over-emphasized.

4) All third and fourth degree frostbite cases received 300,000 units of an aqueous suspension of penicillin intramuscularly daily until their lesions had dried or healed.

5) All patients with second, third and fourth degree frostbite of the feet had their feet cleansed daily with a mild antiseptic solution.

6) Superficial debridement of broken vesicles or necrotic tissue was performed frequently. Suppurative eschars and partially detached toe nails were removed. In the presence of excessive suppuration or necrotic tissue the feet were first thoroughly cleansed with a hydrogen peroxide - aqueous zephiran chloride solution and then soaked in a solution of normal saline for 30 minutes before starting debridement.

7) A nutritious high protein, high vitamin diet supplemented with multiple vitamins was supplied to aid wound healing.

8) All frostbite lesions were exposed to the air and a ward temperature of 70° - 78° F. was maintained.

In addition to the above outlined routine management for all cases of frostbite 109 patients having severe second, third or fourth

degree lesions were selected for treatment with one of six types of specific therapy (Table 33). Selection of these patients was based

TABLE 33

DISTRIBUTION OF 613 CASES OF FIRST, SECOND, THIRD AND FOURTH DEGREE FROSTBITE ACCORDING TO TYPE OF THERAPY ADMINISTERED

Type of Therapy	Degree of Injury								Total
	First		Second		Third		Fourth		
	Feet	Hands	Feet	Hands	Feet	Hands	Feet	Hands	
Routine Management (Control)	211	29	130	49	74	3	5	3	504
Heparin-Alcohol-Procaine	6	0	15	6	34	2	13	2	78
Heparin	2	0	3	0	3	1	1	0	10
Priscoline (oral)	0	0	2	1	1	0	0	0	4
Sympathetic Block	0	0	0	0	1	0	0	1	2
Rutin	0	0	1	2	5	1	0	0	9
Hexamethonium	0	0	2	2	0	2	0	0	6
Total	219	29	153	60	118	9	19	6	613

upon the degree of severity of the injury and the time after rewarming that therapy could be started. Past experimental work with animals has shown that if treatment is to be effective it must be instituted within a period of 6 to 36 hours after injury. Due to delays in evacuation throughout the winter of 1951-52 specific therapy was not instituted in this group of 109 patients until an average of 43 hours had elapsed after rewarming.

The program for each of the six therapeutic regimes was:

1) Heparin. A sufficient amount of aqueous sodium heparin (75-100 mgms.) was administered intravenously every 4 to 6 hours for 10 days in order to maintain clotting

time between 30 and 60 minutes.

2) Heparin-alcohol-procaine. Aqueous sodium heparin added to 250 cc of sterile distilled water which contained 12.5 grams of dextrose, 12.5 cc of 95% ethyl alcohol and 250 mgms. of procaine hydrochloride was administered intravenously by slow drip (60 drops/min.) every 6 hours for a period of 10 days. The amount of heparin added to the solution was that amount (50-100 mgms.) which would maintain the clotting time between 30 and 60 minutes.

3) Rutin. Rutin (500 mgms. daily) was administered orally for a period of 10 days.

4) Priscoline. Fifty mgms. was given orally every 6 hours for 10 days.

5) Hexamethonium (Bistrium). Using the intramuscular route 50 mgms. of hexamethonium were administered every 6 hours for 10 days.

6) Continuous Sympathetic Block. A continuous stellate ganglion block for frostbite of the hands or caudal anesthesia to the level of L-2 for lesions of the feet was maintained for a period of 96 to 120 hours. The stellate ganglion block employed a solution of procaine (2%) and pontocaine (1:1000). A solution of 1.5% metycaine was used to produce a caudal anesthesia.

For purposes of statistical analysis the patients were divided into the following three general treatment groups:

1) Control group. Patients in this group were treated in

accordance with the routine frostbite management and treatment program as already outlined.

2) Anticoagulant group. Patients of this group, in addition to routine management, received either heparin or heparin-alcohol-procaine as described above.

3) Vasodilator group. This group of patients received either priscoline, hexamethonium or a continuous sympathetic block in addition to routine management.

Irrespective of degree of injury the mean vesicular drying time for 184 control patients was 14.6 days, for 41 anticoagulant cases 17.2 days and for four vasodilator cases 8.5 days (Table 34). The anticoagulant group had a significantly longer mean vesicular drying time than did the control or vasodilator group. The shortest drying time was attained by the vasodilator group. In second degree frostbite 128 patients of the control group completed their vesicular drying in 12.3 mean days which was 3.3 days less than the mean time for 19 cases of the anticoagulant group. The differences between the drying time of second degree control and vasodilator cases proved not to be statistically significant. There were no significant alterations in the drying times of vesicles for 79 patients with third degree frostbite when compared to the type of treatment given. It was concluded that the specific therapeutic measures used did not markedly alter the drying time of vesicles when such therapy was initiated on an average of 43 hours after rewarming.

The mean healing times of frostbitten feet irrespective of degree of injury for 172 routine-treated control patients was 33.1 days,

TABLE 34

COMPARISON OF DRYING TIME OF VESICLES FOR 229 CASES OF FROSTBITE WITH RESPECT TO DEGREE OF INJURY AND TYPE OF TREATMENT RECEIVED

Degree of Injury	Treatment Group	No. of Cases	Mean Drying Time (Days)	Standard Deviation	t	P
Second	Combined	150	12.7	± 6.52	5.275	<.001
Third	"	79	19.2	± 9.95		
Combined	Control	184	14.6	± 8.44	1.977	<.05
"	Anticoagulant	41	17.2	± 7.38		
"	Control	124	14.6	± 8.44	2.726	<.01
"	Vasodilator	4	8.5	± 4.27		
"	Anticoagulant	41	17.2	± 7.38	3.566	<.001
"	Vasodilator	4	8.5	± 4.27		
Second	Control	128	12.3	± 6.47	1.999	<.05
"	Anticoagulant	19	15.6	± 6.68		
"	Control	128	12.3	± 6.47	1.056	>.20
"	Vasodilator	3	9.0	± 5.34		
"	Anticoagulant	19	15.6	± 6.68	1.912	>.05
"	Vasodilator	3	9.0	± 5.34		
Third	Control	56	19.7	±10.03	0.540	>.50
"	Anticoagulant	22	18.5	± 8.31		
"	Control	56	19.7	±10.03		
"	Vasodilator	1	7.0	—		
"	Anticoagulant	22	18.5	±10.03		
"	Vasodilator	1	7.0	—		

for 38 anticoagulant patients 48.3 days and for 12 vasodilator cases 38.4 days (Table 35). There was an overloading of first and second degree cases in the control group which accounted for the shorter healing time. Comparisons of the mean healing times of patients with second or third degree frostbite of the feet with respect to type of treatment did not show any significant differences. The rate of wound healing in frostbite of the feet was not accelerated by the use of either heparin, priscoline, hexamethonium or sympathetic blocks as compared to control cases when such therapeutic measures

TABLE 35

COMPARISON OF MEAN HEALING TIME FOR 222 CASES OF FROSTBITE OF THE FEET WITH RESPECT TO DEGREE OF INJURY AND TYPE OF TREATMENT

Degree of Injury	Treatment Group	No. of Cases	Mean Healing Time (Days)	Standard Deviation	t	P
First Second	Combined "	28 104	20.6 25.3	±14.60 ±10.33	1.541	>.10
First Third	" "	28 90	20.6 53.2	±14.60 ±20.17	9.296	<.001
Second Third	" "	104 90	25.3 53.2	±10.33 ±20.17	11.826	<.001
Combined "	Control Anticoagulant	172 38	33.1 48.3	±18.97 ±25.30	3.493	<.001
" "	Control Vasodilator	172 12	33.1 38.4	±18.97 ±21.70	0.824	>.40
" "	Anticoagulant Vasodilator	38 12	48.3 38.4	±25.30 ±21.70	1.322	>.20
Second "	Control Anticoagulant	88 11	25.2 26.5	±10.63 ± 8.30	0.458	>.60
" "	Control Vasodilator	88 5	25.2 24.8	±10.63 ±12.41	0.069	>.90
" "	Anticoagulant Vasodilator	11 5	26.5 24.8	± 8.30 ±12.41	0.271	>.70
Third "	Control Anticoagulant	57 27	51.2 57.2	±17.86 ±25.52	1.106	>.20
Third "	Control Vasodilator	57 6	51.2 53.5	±17.86 ±18.73	0.289	>.70
" "	Anticoagulant Vasodilator	27 6	57.2 53.5	±25.52 ±18.73	0.409	>.60

were initiated on an average of 43 hours after rewarming.

In frostbite of the hands those cases treated with anticoagulants tended to take longer to heal than did the patients who received a vasodilator type of therapy or only routine care (Table 36). Statistical analysis of the hand cases according to type of treatment yielded results similar to those obtained for frostbite of the feet.

Future therapeutic evaluations in frostbite, where treatment

TABLE 36

COMPARISON OF MEAN HEALING TIME OF 59 CASES OF FROSTBITE OF THE HANDS WITH RESPECT TO DEGREE OF INJURY AND TYPE OF TREATMENT

Degree of Injury	Treatment Group	No. of Cases	Mean Healing Time (Days)	Standard Deviation	t	P
First Second	Combined "	4 49	22.8 21.7	±11.13 ± 8.94	0.189	>.80
First Third	" "	4 6	22.8 48.0	±11.13 ±25.46	2.142	>.05
Second Third	" "	49 6	21.7 48.0	± 8.94 ±25.46	2.515	<.02
Combined "	Control Anticoagulant	44 7	21.1 38.4	± 8.82 ±25.44	1.790	>.05
" "	Control Vasodilator	44 8	21.1 30.8	± 8.82 ±16.46	1.625	>.10
" "	Anticoagulant Vasodilator	7 8	38.4 30.8	±25.44 ±16.46	0.683	>.40
Second "	Control Anticoagulant	40 4	20.9 30.8	± 8.85 ±10.64	1.794	>.05
" "	Control Vasodilator	40 5	20.9 20.8	± 8.85 ± 7.22	0.023	>.90
" "	Anticoagulant Vasodilator	4 5	30.8 20.8	±10.64 ± 7.22	1.599	>.10
Third "	Anticoagulant Vasodilator	3 3	48.7 47.3	±43.51 ±11.38	0.052	>.90

is initiated less than 43 hours after injury, will have to take into proper account such factors as the duration of exposure, methods used to rewarm, type of boot or handgear worn, and condition of the extremity at the time of injury for each individual case before any given type of therapy might be shown to be more efficacious than another. Such an evaluation would of necessity require a very painstaking factor analysis. An accurate therapeutic evaluation would also be dependent upon an early correct classification of the cold injury. The criteria for classifying frostbite lesions as to degree of severity becomes less distinct as the time interval between rewarming

and examination of the patient shortens so that at time of rewarming all frostbitten parts usually have a similar clinical appearance. Another important factor that will have to be considered in a therapeutic evaluation is the area involvement. It is emphasized that the clinical evaluations just presented do not take into consideration the total area of cold injury involvement, case by case.

V. DURATION OF HOSPITALIZATION

The duration of hospitalization covered the period which started with the evacuation of the patient from a front-line medical facility and ended when he was either transferred from the Cold Injury Center in Osaka, Japan, to a reconditioning center in Nara, Japan, for duty, or discharged from Percy Jones Army Hospital, Battle Creek, Michigan, to duty. Table 37 shows the mean hospital days for 585 frostbite cases according to their degree of injury and anatomical site of involvement. The length of hospitalization for patients with frostbite of the hands was less than that for patients with involvement of the feet of like degree. In fourth degree frostbite the hand cases required 94 less days of hospitalization. Irrespective of degree of injury or anatomical site of involvement 585 patients with frostbite required 31.3 mean days of hospitalization. Exclusive of fourth degree cases, the 1950-51 frostbite casualties required 32.4 mean days of hospitalization, and the 1951-52 patients required 25.8 mean days before they could be transferred to a reconditioning center.

Table 38 shows the mean duration of hospitalization for 630 cases of first, second and third degree frostbite with respect to the type of treatment given while hospitalized. The data suggest

TABLE 37

MEAN DAYS OF HOSPITALIZATION WITH STANDARD DEVIATIONS FOR FIRST, SECOND, THIRD AND FOURTH DEGREE FROSTBITE OF THE HANDS AND FEET FOR 1951-52

Site of Injury	Degree of Injury														
	First			Second			Third			Fourth			Total		
	No. of Cases	Mean Days	Standard Deviation	No. of Cases	Mean Days	Standard Deviation	No. of Cases	Mean Days	Standard Deviation	No. of Cases	Mean Days	Standard Deviation	No. of Cases	Mean Days	Standard Deviation
Feet	207	15.3	±8.02	146	23.9	±13.38	111	47.5	±24.62	20	196.3	±16.01	484	32.8	±39.24
Hands	29	15.2	±7.76	59	19.4	± 8.71	8	46.6	±21.18	5	102.0	±90.93	101	24.4	±26.91
Total	236	15.3	±7.94	205	22.6	±12.33	119	47.4	±24.26	25	195.2	±53.86	585	31.3	±37.58

TABLE 38

MEAN DAYS OF HOSPITALIZATION FOR 630 CASES OF FROSTBITE
ACCORDING TO DEGREE OF INJURY
AND TYPE OF TREATMENT

Degree of Injury	Treatment Groups											
	Control			Anticoagulant			Vasodilator			Total		
	No. of Cases	Mean Days	Standard Deviation	No. of Cases	Mean Days	Standard Deviation	No. of Cases	Mean Days	Standard Deviation	No. of Cases	Mean Days	Standard Deviation
First	248	16.1	±11.42	8	21.9	±12.06	2	16.0	± 2.00	258	16.3	±11.39
Second	198	22.5	±18.89	30	29.4	±12.29	10	20.3	± 7.01	238	23.3	±17.98
Third	83	43.8	±24.18	40	55.7	±25.93	11	57.6	±23.42	134	48.4	±25.22
Total	529	22.8	±19.39	78	42.1	±24.75	23	37.8	±25.54	630	25.8	±67.74

that the use of anticoagulants caused an increase in the period of hospitalization regardless of the degree of injury.

VI. DISPOSITION

Six percent of the 716 frostbite patients admitted to the cold injury centers were evacuated to hospitals in the Zone of Interior (Table 39). During the winter of 1950-51 18% of the

TABLE 39

DISPOSITION OF 716 CASES OF FROSTBITE FOR THE WINTER OF 1951-52

Disposition of the Patients	First		Second		Third		Fourth		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%
General Duty	120	37.3	8	3.5	0	0	0	0	128	17.9
Limited Duty	122	37.9	10	4.4	3	2.3	0	0	135	18.9
Recondition Center Limited Duty	73	22.7	191	83.8	97	72.9	3	9.1	364	50.8
Recondition Center General Duty	4	1.2	16	7.0	26	19.5	0	0	46	6.4
Zone of Interior	3	0.9	3	1.3	7	5.3	30	90.9	43	6.0
Total	322	100.0	228	100.0	133	100.0	33	100.0	716	100.0

frostbite patients were returned to the Zone of Interior. Two hundred sixty-three patients were returned directly to general or temporary limited duty from the Korean cold injury center. The cold injury center of Osaka Army Hospital returned to general duty or temporary limited duty 410 patients via a reconditioning center. The average length of stay at the reconditioning center was 14 days. The period of limited duty for all cases expired on 1 May 1952. Prior to this expiration date the reclassified soldier was not assigned to a front-line combat unit in order to protect him from

re-exposure to low environmental temperature because of a possible increased susceptibility to cold injury.

Out of 664 cases of frostbite 129 patients (19.4%) gave a history of having had either frostbite or trenchfoot prior to the winter of 1951-52. Among the 1950-51 group of frostbite casualties 14.9% gave a history of previous cold injury before the winter of 1950-51. A positive history of previous cold injury meant that the patient either had knowledge or record of diagnosis confirmed by a physician or he was able to relate confirmatory events in his cold injury experience such as: ambient temperature during exposure, length of exposure, symptoms of the involved part during exposure and after rewarming, skin changes after injury and the presence or absence of vesicles and/or ulcerations.

If those soldiers with a history of previous cold in‹›ry had been removed from the front-line combat units prior to the onset of cold weather in 1951-52 the incidence rate of frostbite in the Eighth Army for the winter would have been reduced by 8%. On the basis of exposure the attack rate among those with a history of previous cold injury was 5.0 per 1,000 while those without such a history had an attack rate of 2.6 per 1,000.

VII. SUMMARY AND CONCLUSIONS

A total of 716 confirmed cases of frostbite were evaluated with respect to possible contributing factors, anatomical site, severity of injury and therapy. A comparison of the incidence figures for 1950-51 with those for 1951-52 revealed the fact that there was a marked reduction in the severity of cold injuries for the latter

period. In the 1951-52 period the rates of feet to hand cases was approximately 3 to 1.

Soldiers who have had a previous authenticated frostbite should be reclassified to limited duty on a semi-permanent basis. Their duty assignments should prevent them from exposure to low ambient temperatures.

The most objective criteria employed to assess the relative importance of the factors contributing to cold injuries concerned the amount of time required for drying of the vesicles and healing of the lesions. The effect of the various factors upon the clinical course of frostbite were:

1) The drying time of vesicles and the healing of frostbite lesions was dependent upon the degree of injury, in that first and second degree lesions which were of approximately the same order required less time than did third degree injuries. The clinical course of the injuries was not influenced by the anatomical site of the lesions except in second degree where the healing rate for hand cases was shorter than for feet.
2) The drying time of vesicles and the healing of the frostbite lesions was not dependent upon the race of the patient.
3) Cold exposures over 8 hours increased the vesicular drying time of second degree lesions and prolonged the healing of second degree frostbite of the feet. The healing of first and third degree lesions of the feet and all lesions of

the hands, however, was not prolonged by longer periods of exposure.

4) The vesicular drying time was shorter in cases of third degree frostbite rewarmed by a room temperature exposure as compared to similar lesions rewarmed by walking, exposure to an open fire or by massage. Third degree lesions of the feet rewarmed by a room temperature exposure took less time to heal than did equivalent injuries where rewarming was accomplished by walking, massage or exposure to an open fire. The healing of first and second degree frostbite of the feet and all lesions of the hands was not adversely affected by any one single method of rewarming.

5) When the delay in evacuation after injury was over 24 hours the drying time of vesicles was prolonged in cases of second degree frostbite. The factor of delay in evacuation also prolonged the healing of first degree frostbite of the feet. Healing of second and third degree frostbite of the feet and all lesions of the hands was not affected by this factor.

6) The drying time of vesicles in second and third degree frostbite of the feet was increased when the injury was incurred in leather boots as compared to similar patients wearing the shoepac or rubber insulated boot. The healing time for first, second and third degree frostbite was greater in those cases wearing leather boots as compared

with similar patients equipped with shoepacs or insulated boots.

7) The type of handgear (or absence thereof) worn at time of injury did not alter the drying time of vesicles or the healing rate of frostbite lesions of the hands.

8) A longer vesicular drying time for second degree frostbite occurred when the pre-injured extremity was wet. The healing of frostbite of the hands or feet was not influenced by the factor of wetness or dryness at time of injury.

9) Specific therapy instituted 43 hours after injury did not materially alter the clinical course of frostbite.

In these evaluations, the differences in healing times, small as they may appear, could assume gigantic proportions in terms of manpower loss and hospital cost when multiplied by hundreds of cases.

VIII. RECOMMENDATIONS

It is evident that the placing of a frostbite casualty on a temporary limited duty status will not suffice for preventing him from being re-exposed to cold within 2 to 3 years after injury. In view of the experience in Korea during the winters of 1950-51 and 1951-52 it is recommended that confirmed cases of cold injury be given a profile of L-3 or U-3 for a period of 5 years from time of injury. It is further recommended that the duty assignments of such reprofiled military personnel should be governed by the following criteria:

1) No preferential duty assignment will be necessary for locales where the mean minimum temperatures for the

coldest months is above 25° F.

2) The duty assignment must assure no prolonged outside exposure for locales where the mean minimum temperature for the coldest months is below 25° F.

3) No personnel reprofiled because of frostbite should be assigned to locales where the mean minimum temperature for the coldest months is below 0° F.

SECTION VI

THE TREATMENT OF THIRD DEGREE FROSTBITE BY SKIN GRAFTING

by

Robert E. Lempke
1st Lt. MC, AUS

TABLE OF CONTENTS

THE TREATMENT OF THIRD DEGREE
FROSTBITE BY SKIN GRAFTING

I. INTRODUCTION

The slow rate of healing of third degree frostbite ulcers of the toes is responsible for a large portion of the time patients with this lesion are hospitalized. The resultant loss of manpower and the effect of the prolonged state of invalidism upon the morale of the individual are significant. Therefore an investigation of the possibility of hastening the restoration of epithelial continuity in these cases by the application of skin grafts was undertaken.

II. METHOD

The location and size of the lesions decided the type of skin graft used. Split thickness grafts would not, in all probability, be able to withstand the trauma to which they would be subjected on the tips of the toes. Furthermore the size and site of the lesions did not warrant such a major procedure as a pedicle flap although in some instances it would have yielded the best results. Therefore, fre small, full skin thickness (pinch) grafts were used.

The lesions chosen for grafting were third degree frostbite ulcerations which at the time of their selection were completely debrided of necrotic tissue either surgically or spontaneously and were approximately one square centimeter or more in area. The pinch grafts were taken from the upper lateral aspect of the thigh under aseptic conditions. A field

block was performed with a 1% solution of procaine to anesthetize the donor site. The excised skin was placed on the base of the ulcer which had previously been cleansed thoroughly with an aqueous solution of zephiran chloride (1:1000). It was secured with a dressing of a single layer of gauze lightly impregnated with petroleum jelly and several layers of dry gauze. Bed rest and a foot cradle were employed to minimize mechanical trauma to the grafts. The dressings were changed on the third post-operative day and daily thereafter. Some of the patients were treated with Bistrium (hexamethonium bromide) administered intramuscularly in 50 mgm. doses at 6-hour intervals according to one of two regimens differing only in the time at which therapy was initiated. In Method 1 treatment with Bistrium was started at the time of application of the grafts. In Method 2 it was started one or two days before the operation. In either case treatment was continued until the ulcer had healed.

III. RESULTS

The results are summarized in Table 1. A total of 40 pinch grafts were applied to 13 ulcer beds on the toes of 11 patients. Six grafts were placed on the bases of two ulcers, one in each of two patients who received no other treatment. None of these untreated or control grafts survived. Thirty-four grafts were transferred to 11 ulcer sites on the toes of nine patients who received Bistrium according to one or the other above mentioned therapeutic regimens. The transplanted skin survived in 21 instances and sloughed in 13 instances.

Statistical analysis of these results using the chi square test with Yate's correction for continuity yielded a value of 5.522. The probability that the difference between the results in the control and the Bistrium treated series was due to chance is less than 2%.

TABLE 1

THE FATE OF PINCH GRAFTS APPLIED TO THIRD DEGREE FROSTBITE ULCERS OF THE TOES

Treatment	Patients	Ulcers	Grafts	Fate of Grafts	
				Survival	Non-survival
None	2	2	6	0	6
Bistrium (1)	7	7	24	11	13
Bistrium (2)	2	4	10	10	0

(1) Method 1: Bistrium 50 mgm. I.M. q6h starting at time of skin grafting.

(2) Method 2: Bistrium 50 mgm. I.M. q6h starting one or two days before skin grafting.

The two methods of Bistrium administration were not equally effective. When therapy was instituted at the time of the operative procedure (Method 1) only 11 of 24 grafts survived, while all ten grafts survived when treatment was started one or two days before the operation (Method 2). This difference was statistically significant; chi square equaled 6.626, $P < .02$. The results obtained with the former therapeutic regimen were not significantly different from those obtained with no treatment (chi square equaled 2.593, $P > .10$); while the latter method of Bistrium administration significantly improved the results

over those obtained in the control subjects (chi square equals 12.015, P <.001).

Eight of the unsuccessful grafts in the group which were treated with Bistrium by Method 1 were on ulcer sites in two patients who were particularly uncooperative about remaining in bed. It was considered quite probable that failure to survive was due to trauma and the consequent lack of immobilization of the grafts on the ulcer bed. If these grafts were omitted from the statistical analysis the results in this series became significantly better than in the control group (chi square equaled 5.729, P <.02), and they more closely approached the excellent results in the group of patients treated with Bistrium before as well as after grafting (chi square equaled 2.119, P >.10).

The incidence of grossly evident infection of the grafted ulcers did not vary significantly between the treated and control series. One of the two untreated ulcer sites became infected as compared to two of the nine vasodilator-treated ulcers. The chi square test yielded a value of 0.005, P >.90.

The accompanying photographs illustrate results typical of the successful attempts to graft frostbite ulcers. Figures 1, 2 and 3 show the progress of a large ulceration on the tip of the right great toe of a 27 year old negro soldier. The lesion had been completely debrided of necrotic tissue 23 days after injury. Twelve days later when the base of the ulcer had an area of 2.80 square centimeters, five pinch grafts were applied to it and treatment with Bistrium, 50 mgm. intramuscularly

every 6 hour , was started. Figures 1 and 2 show the ulcer and the grafts 6 and 16 days after the operation. In the latter figure the site of the ulcer was re-epithelialized except for a small fissure between two of the grafts. In Figure 3, 63 days after injury, 40 days after debridement and 28 days after grafting, the ulcer was completely covered with epithelium.

In Figures 4 and 5 are shown the results obtained in t.. case of a 38 year old white soldier who had sustained a less extensive third degree frostbite injury. The former figure depicts the third degree ulcer of the left great toe with two pinch grafts in place 37 days after injury and 5 days after surgical debridement and grafting. Vasodilator therapy was instituted at the time of the operation. The photograph in Figure 5, 72 days after frostbite and 40 days after surgery reveals that the medial one of the two grafts blended impercep-tible with the surrounding skin. Only the derma of the lateral graft survived.

IV. DISCUSSION

The value of vasodilating procedures and drugs in facilitating the healing of cutaneous lesions of the extremities is well known. Although there is evidence that drugs which produce generalized vasodilatation are less effective than local sympathetic denervation in this respect, the results with Bistrium in this study were dramatic. The ulcers of control patients were pale and cold whereas those of the treated subjects were pink or red, warm and bled ea y. It was obvious that free skin grafts

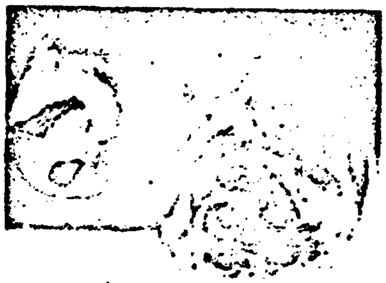


FIGURE 1. A THIRD DEGREE FROSTBITE ULCER OF A RIGHT GREAT TOE 38 DAYS AFTER INJURY AND 6 DAYS FOLLOWING THE APPLICATION OF 5 PINCH GRAFTS.

FIGURE 2. THE SAME LESION AS SHOWN IN FIGURE 1, 41 DAYS AFTER INJURY. THE ULCER HAS RE-EPITHELIALIZED EXCEPT FOR A SMALL AREA MEDIAL TO THE CENTRAL GRAFT.

FIGURE 3. THE SAME LESION AS SHOWN IN FIGURES 1 AND 2, 63 DAYS AFTER INJURY AND 28 DAYS AFTER SKIN GRAFTING. THE ULCER HAS HEALED.

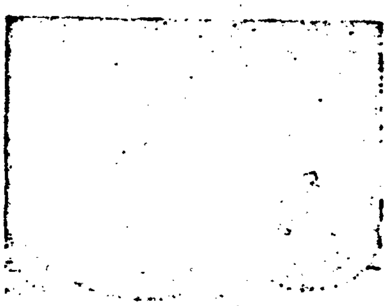


FIGURE 4. A THIRD DEGREE FROSTBITE ULCER OF A LEFT GREAT TOE 37 DAYS AFTER INJURY AND 5 DAYS FOLLOWING THE APPLICATION OF 2 PINCH GRAFTS.

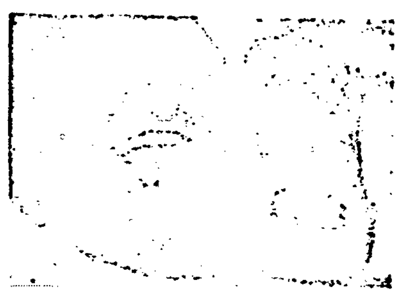


FIGURE 5. THE SAME LESION AS SHOWN IN FIGURE 4, 40 DAYS AFTER SKIN GRAFTING. THE MEDIAL GRAFT HAS BLENDED IMPERCEPTIBLY WITH THE SURROUNDING SKIN. THE SUPERFICIAL LAYERS OF THE LATERAL GRAFT HAVE SLOUGHED.

would not survive on the poorly vascularized ulcer beds of the former group and the control series therefore was abbreviated. The survival of the grafts in the treated subjects was an indication of the increase in effective blood flow through the ulcer bed produced by Bistrium therapy. The greater survival rate of skin grafts in those subjects who were given the drug one or two days before the operation was probably due to the better vascularization of the base of the ulcers.

Treatment with a potent vasodilator alone would probably reduce the healing time of these ulcers as much as the combination of the drug and the application of pinch grafts. Data on the rate of healing of third degree frostbite lesions with and without skin grafting and also in the presence and absence of vasodilator therapy was collected. The results of analysis of these data were inconclusive due to the small number of observations and the variability among the lesions initially. However, the clinical impression that was gained while caring for these patients and the data collected tended to confirm the impression that treatment with Bistrium, either alone or in conjunction with skin grafting, decreased the time required for restoration of epithelial continuity in cases of third degree frostbite. The addition of skin grafts had the effect primarily of producing a thicker covering of the ulcer site than did spontaneous re-epithelialization. Also in the case of the smaller ulcerations as illustrated in Figures 4 and 5 the pinch grafts frequently

filled in the defect so as to obliterate it completely.

A long term study to determine the fate of the grafted skin on the tips of the toes was not possible. However, the fact that in many instances the grafts were identical in appearance to the surrounding skin suggested that they were durable.

V. CONCLUSIONS

The effective circulation in toes with third degree frostbite was inadequate to produce survival of pinch grafts. Presumably this deficiency in the circulation was responsible for the slow rate of healing of these lesions. Treatment of the patient with a potent vasodilator drug, Bistrium, facilitated the survival of pinch grafts especially when the ulcer bed was prepared by administration of the drug for one or two days before the operation. Although it could not be proven statistically, treatment of third degree frostbite ulcers with Bistrium and pinch grafts definitely appeared to decrease the time required for complete re-epithelialization of these lesions.

ARMY MEDICAL RESEARCH LABORATORY

FORT KNOX, KENTUCKY

AD NO. 22438-H

FILE COPY

REPORT NO. 113
1 April 1953

COLD INJURY - KOREA 1951-52*

Section VII
FOOT CONDITIONS IN THE SEVERAL TYPES OF BOOTGEAR UNDER COMBAT CONDITIONS, KOREA, 1951-52

*Subtask under Environmental Physiology, AMRL Project No. 6-64-12-028, Subtask (8K), Cold Injury Studies.

D

MEDICAL RESEARCH AND DEVELOPMENT BOARD
OFFICE OF THE SURGEON GENERAL
DEPARTMENT OF THE ARMY

SECTION VII

FOOT CONDITIONS IN THE SEVERAL TYPES OF BOOTGEAR UNDER COMBAT CONDITIONS KOREA, 1951-52

by

Sylvan L. Weinberg
Capt. MC, AUS

TABLE OF CONTENTS

FOOT CONDITIONS IN THE SEVERAL TYPES OF
BOOTGEAR UNDER COMBAT CONDITIONS
KOREA, 1951-52

I. INTRODUCTION

During the winter of 1951-52, a new type of combat boot was introduced for use by front-line troops under wet-cold environmental conditions in Korea. This boot, known technically as the "boot, combat, rubber, insulated", employed the vapor barrier principle and provided a synthetic wool layer separating two sealed rubber layers. Insulation thus achieved seemed superior to previously available combat bootgear. The new boot was hailed widely as an effective instrument for the reduction of cold injuries. However, shortly after its introduction, in Korea certain criticisms of the boot arose. Among these were apparent increases in erythema, hyperhidrosis, tissue maceration and fungus infection of the feet. In certain instances, particularly where foot hygiene was poor, sock change inadequate, and where boots were worn continuously for periods of 48 hours or more, erythema, tissue maceration and hyperhidr[illegible] so severe as to produce an incapacitating foot syndrome. T[illegible] was marked by tenderness of the feet to the degree th[illegible]ing [illegible]emely painful. Physical examination of the feet revealed a [illegible]scoloration and a peculiar softening and wrinkling of the skin. Sweating was profuse. Tissue maceration in advanced cases was pronounced enough to cause denudation of extensive plantar skin areas. In many cases the picture was complicated by superimposed fungus infection. This factor often caused difficulty in distinguishing the sequelae due to the use of the boot and/or from the effects of the infectious process.

Illustrative of the undesirable effects which may occur from the use of the boot, was that which occurred in one of the United States infantry battalions in Korea during January 1952. This battalion, in a reserve area, conducted a maneuver involving 3 days of extensive marching and long periods of guard duty, during which time the men were unable to remove their boots and perform foot hygiene. Following this action a thorough foot check revealed that more than 12% of 700 men, all of whom had worn the new insulated boot, had incapacitating foot findings consisting of varying degrees of erythema, tissue maceration, denudation of the soles of the feet and hyperhidrosis. Also there were 10 new cases of severe fungus infection found in the battalion. Other reports of insulated boot sequelae of a similar character were circulated, but many of these were largely fragmentary and hearsay in character.

A survey was therefore undertaken in mid-March 1952 to gain specific information concerning the experience with the new boot among a sampling of infantrymen from the 3 regiments of the United States 25th Division in Korea. Additional information, in the form of a brief subjective impression of the new formula V* anhidrotic foot powder, was obtained from the troops interviewed.

II. METHODS AND MATERIAL

Two hundred eighty-one men from the 14th, 27th and 35th Infantry Regiments were interrogated concerning their impressions of the insulated rubber combat boot. During the interview their feet were examined for gross evidence of epidermophytosis, erythema, hyperhidrosis and tissue maceration. No effort was made to grade epidermophytosis in de-

* Aluminum Chloride 3%; Boric acid 7%; Potassium aluminum sulfate 10%; Salicylic acid 3%; Powdered corn starch 5%; Powdered Talc 72%.

degrees of severity. Minimal criteria for this diagnosis were the presence of scaling and/or fissuring. No laboratory techniques were employed. It was realized that under these conditions certain errors were unavoidable. However, it was believed that by gross inspection general trends of incidence of fungus infection could be established.

Hyperhidrosis, maceration and erythema, when present, were graded as mild, moderate and severe. This breakdown appears in the tables, but for the purposes of statistical analysis only the presence or absence of the respective conditions was considered.

Ninety-three infantrymen of the 14th Infantry Regiment were interrogated and examined at their battalion rear areas within 2 hours after arrival from front-line positions. Seventy-three soldiers of the 27th Infantry Regiment were seen at their regimental reserve area. One hundred fifteen members of the 35th Infantry Regiment were met at a shower point immediately after they arrived from positions in the main line of resistance.

III. RESULTS

A. Subjective Impressions of the Insulated Boot. (Table 1)

One hundred ninety-five of the 281 men interviewed had had experience in wearing both the new boot and shoepac. Of these, 72 (36.9%) volunteered no complaint concerning the new boot. One hundred twenty-three (63.1%) were troubled by what they called "excessive" sweating.

An effort was made, where possible, to elicit subjective comparisons between the new insulated boot and the shoepac. One hundred forty-seven (75.3%) of the men who had worn both indicated that sweating seemed greater with the new boot. Four-

teen (7.2%) considered that less sweating was present with the insulated boot. Thirty-four (17.4%) could observe no difference. Sixty-seven (34.3%) men felt that foot discomfort was more pronounced in the shoepac, while 38(19.5%) thought it greater in the insulated boot. Ninety (46.1%) could discern no difference.

TABLE 1

SUBJECTIVE IMPRESSION OF THE INSULATED BOOT

Regiment	No. of Cases	No complaint	Sweating Increased	Comparison of the Insulated Boot with the Shoepac					
				Sweating			Foot Discomfort		
				More	Less	Same	More	Less	
14th	48	13	35	40	1	7	1	22	25
27th	73	39	34	52	7	14	24	19	30
35th	74	20	54	55	6	13	13	26	35
Total	195	72 (36.9%)	123 (63.1%)	147 (75.3%)	14 (7.2%)	34 (17.4%)	38 (19.5%)	67 (34.3%)	90 (46.1%)

It was the impression of the examiners that the over-all subjective response of the troops to the boot was favorable. Many of the men who commented on increased sweating and foot discomfort nevertheless preferred the new boot because of its greater warmth and water repellent qualities. A frequent comment elicited suggested that the so-called foot irritation decreased after the individual became conditioned to the boot. Many of the complaints registered arose when the boot was worn during relatively mild weather conditions when sweating was usually exaggerated. It must be kept in mind that the sub-

jective impression of increased sweating does not constitute proof that sweating actually was increased. It may be that consciousness of sweat was more marked since there was less opportunity for absorption by the single pair of wool socks and none by the rubber lined boot interior as compared with the two pair of heavy ski socks and felt insole worn with the shoepac.

B. Condition of the Feet.

1. Epidermophytosis (Table 2)

Of the 281 men studied, 146 were wearing the insulated boot at the time of examination. Forty-nine others were wearing the leather combat boot at examination but had worn the new boot for varying periods of time shortly prior to this study. Sixty-five men (44.5%) of the insulated boot group had gross evidence of epidermophytosis. Twenty-one men (42.9%) of the group who had worn the new boot previously had similar involvement. A comparison of these two percentages, utilizing the standard deviation of proportions, revealed a difference of 1.6% or 0.34 sigma. This indicated that there was no significant difference in the incidence of epidermophytosis between those wearing the insulated boot at the time of examination and those who had removed this boot in favor of the leather combat boot several days prior to examination.

Of the total group of 281 men, 86 had never worn the new boot and were clad either in the shoepac (64) or the leather combat boot (22) when seen. Of the 64 men wearing the

shoepac, 19 (29.7%) had gross evidence of epidermophytosis. Among t e 22 who were wearing the combat boots, 4 (18.2%) revealed evidence of fungus infection. The difference in incidence of epidermophytosis between thses two groups was 11.5% or 1.05 sigma. This suggests that the incidence of epidermophytosis was not significantly different among those wearing the shoepac as compared with those wearing the leather combat boot. Thus a total of 23 men (26.7%) of the 86 who had never worn the insulated boot had evidence of epidermophytosis. Comparing the percentages of epidermophytosis in those who had worn the insulated boot with those who had never worn them, a difference of 17.3% or 2.9 sigma was found. Such a difference in the percentage of occurrence of epidermophytosis in the two groups could be expected to occur by chance alone once in 267 times. The inference was that the wearing of the insulated boot contributed significantly to an increased incidence of epidermophytosis. This inference was further strengthened by the fact that 73 soldiers examined from the 27th Infantry Regiment (Table 2) had worn the new boot either at examination or shortly before. The 27th Infantry Regiment was the only one of the three studied which was in a regimental reserve area at the time of the survey. In the reserve area, where opportunities for proper foot hygiene were better than at the front lines, the 73 men who had worn the insulated boot still had a higher incidence of fungus infection (41.1%) than the 86 men in actual com-

bat who were wearing the shoepac or the leather boot (26.7%).

TABLE 2

INCIDENCE OF EPIDERMOPHYTOSIS AMONG 281 COMBAT SOLDIERS ACCORDING TO TYPE OF BOOTGEAR WORN KOREA, 1951-52

Bootgear Worn at time of Examination	History of Having Worn Insulated Boot		History of not Having Worn Insulated Boot	
	No. of Cases	Evidence of Epidermophytosis	No. of Cases	Evidence of Epidermophytosis
Insulated Boot	146	65 (44.5%)	—	—
Shoepac (Rubber)	—	—	64	19 (29.7%)
Leather Boot	49	21 (42.9%)	22	4 (18.2%)
Total	195*	86 (44.0%)	86**	23 (26.7%)

*Includes 73 soldiers for the 27th Regiment in reserve among whom 30 (41%) had evidence of epidermophytosis

**Soldiers examined immediately after arrival from front-line positions

2. Erythema, Hyperhidrosis and Maceration

As has been stated previously, of the 195 men who had worn the insulated boot (Table 3, Group I a), 146 were wearing it at the time of examination. The remaining 49 men had recently changed to the leather combat boot. Among the 146 men wearing the new boot, 56 (38.3%) had evidence of hyperhidrosis, 56 (38.3%) showed maceration and 80 (54.7%) revealed erythema. Considering these manifestations in the 49 men wearing the combat boot (Table 3 Group 1, b), there were nine (18.4%) cases of hyperhidrosis, five (10.2%) of maceration and 18 (36.7%) of

erythema. Comparing these percentages by the method of standard deviation of proportions (Table 4, Group I) it was found that there were significant differences between the two groups in the respective incidence of hyperhidrosis, maceration and erythema. This indicated that unlike the situation described previously with regard to epidermophytosis, hyperhidrosis, maceration and erythema were significantly decreased in incidence by removal of the insulated rubber boot in favor of the combat boot - even for a brief period of a few days prior to examination.

In order to evaluate further the role of the insulated boot in the production of hyperhidrosis, maceration and erythema, a sampling of front-line soldiers who had never worn this type of bootgear was examined for purposes of comparison. This group included 86 men, 64 of whom were wearing the shoepac and 22 the leather combat boot at the time of examination. The incidence of hyperhidrosis, maceration and erythema among these men is shown in Table 3, Group II. In Table 4, it is demonstrated that there was no significant difference in the respective percentages of occurrence of hyperhidrosis, maceration and erythema among the 64 men wearing the shoepac and the 22 wearing the leather combat boot. In the third section of Table 4 the percentages of hyperhidrosis, maceration and erythema among troops who had recently changed from the insulated boot to the leather combat boot and those who had worn only the shoepac or the leather combat boot are com-

TABLE 3

INCIDENCE OF HYPERHIDROSIS, MACERATION AND ERYTHEMA AMONG 195 COMBAT SOLDIERS WHO HAD WORN THE NEW INSULATED RUBBER BOOT AND AMONG 86 COMBAT SOLDIERS WHO HAD NOT WORN THE NEW INSULATED RUBBER BOOT KOREA, 1951-52

Footgear Worn	No. of Cases	Hyperhidrosis				Maceration				Erythema			
		None	Mild	Mod.	Severe	None	Mild	Mod.	Severe	None	Mild	Mod.	Severe
Group I: History of having worn the Insulated Boot. a. Insulated Boot worn at time of exam.	146	90	41	13	2	90	26	27	3	66	54	21	5
		(62%)	56(38%)			(62%)	56(38%)			(45%)	80(55%)		
b. Combat Boot worn at time of exam.	49	40	8	0	1	44	4	0	1	31	17	0	1
		(82%)	9(18%)			(90%)	5(10%)			(63%)	18(37%)		
Group II: History of never having worn the Insulated Boot. a. Shoepac worn at time of exam.	64	55	7	1	1	55	8	0	1	54	7	2	1
		(86%)	9(14%)			(86%)	9(14%)			(84%)	10(16%)		
b. Combat Boot worn at time of exam.	22	21	1	0	0	21	1	0	0	18	3	1	0
		(96%)	1(5%)			(96%)	1(5%)			(82%)	4(18%)		
Total	86	76	8	1	1	76	9	0	1	72	10	3	1
		(88%)	10(12%)			(88%)	10(12%)			(84%)	14(16%)		

TABLE 4

COMPARISON OF STANDARD DEVIATIONS OF PERCENTAGES IN TABLE 3

		Part a	Part b	Difference S. D. %	Inference
Section 1	Group I: (Table 3)				Percentages in parts a and b are significantly different. (Change from the Insulated Boot to the Combat Boot a few days prior to examination reduced significantly the incidence of Hyperhidrosis, Maceration and Erythema.)
	Percent with Hyperhidrosis	38.3	18.4	2.9	
	Percent with Maceration	38.3	10.2	4.8	
	Percent with Erythema	54.3	36.7	2.2	
Section 2	Group II: (Table 3)				Percentages in parts a and b are not significantly different. (There was no significant difference in the incidence of Hyperhidrosis, Maceration and Erythema in soldiers wearing the shoepac and leather combat boot, who had never worn the insulated rubber boot.)
	Percent with Hyperhidrosis	14.1	4.5	1.5	
	Percent with Maceration	14.1	4.5	1.5	
	Percent with Erythema	15.6	18.2	0.27	
Section 3	Table 3	Group I Part b	Group II Part a&b	Difference S. D. %	Difference in percentages for Hyperhidrosis and Maceration are not significant. Those for Erythema are significantly different. (Replacement of the insulated boot with the leather combat boot prior to examination reduced in the incidence of Hyperhidrosis and Maceration to that seen in Troops who had never worn the insulated boot. Incidence of Erythema, however, remained significantly higher.)
	Percent with Hyperhidrosis	18.4	11.6	1.1	
	Percent with Maceration	10.2	11.6	0.25	
	Percent with Erythema	36.7	16.3	2.7	
Section 4	Table 3	Group I Part a	Group II Part a&b		Percentages in part a, Groups I and II, parts a and b, Group II are significantly different. (The incidence of Hyperhidrosis, Maceration and Erythema was significantly higher in the group wearing the insulated boot at examination as compared with those wearing the shoepac or the leather combat boot, who had never worn the insulated boot.)
	Percent with Hyperhidrosis	38.3	11.6	5.1	
	Percent with Maceration	38.3	11.6	5.1	
	Percent with Erythema	54.7	16.3	6.8	

pared. These differences in percentages were not significant in the case of hyperhidrosis and maceration, however, they were significant where erythema was concerned. It was therefore concluded that whatever effect the insulated boot may have had in the production of hyperhidrosis and maceration it was reversible by replacing this bootgear by the leather boot for a brief period of several days. The minimal period required has not been determined. However, it was apparent from the data that erythema persisted in higher incidence even after the change from the insulated boot to the leather combat boot. The significance of this finding was not entirely clear but it may be postulated that since erythema was the earliest finding to appear when the insulated boot was worn for unduly long periods of time it may also be the last finding to remain in the reversal of the process.

The final step remaining in evaluating the effect of the insulated boot is the comparison of percentages of hyperhidrosis, maceration and erythema in troops wearing the new insulated rubber boot at the time of examination with those men who have never worn them. In Table 4, Section 4, differences in percentages in these three manifestations are significant. This seems clearly to indicate that hyperhidrosis. maceration and erythema exist in higher order of frequency among combat soldiers (whose activities and equipment are otherwise comparable) when wearing the new insulated rubber boot than when wearing the shoepac or

the leather combat boot. The data further suggested that removal of the new boot and change to a different type of bootgear will limit the incidence of maceration and hyperhidrosis even in a man who had worn the new boot in recent days prior to examination. The residual finding of erythema, however, and fungus infection, the latter a more chronic process, was shown to remain elevated in incidence for an undetermined period of time even after removal of the new boot.

Of the 281 men included in this study, 33 (11.1%) were Negro. This represented a sampling consistent with the over-all Eighth Army percentage of Negro troops at the regimental level. However, the absolute number of Negro troops examined was too small to permit statistical comparison of incidence of the various phenomena described, on a racial basis.

C. Subjective Evaluation of the formula V foot powder.

Two hundred and nine of the entire group of 281 men had experience with the use of the foot powder. Of these, 31 volunteered the complaint of caking. Forty-one observed no benefit from the powder. One hundred sixty-three considered that sweating was limited by the foot powder. A breakdown of these data is seen in Table 5.

TABLE 5

SUBJECTIVE IMPRESSION OF FORMULA V FOOT POWDER

Regiment	No. of Cases	Complaints Caking	Complaints Misc.	Sweating Reduced	No Benefit
14th	67	10	4	50	15
27th	58	7	2	43	14
35th	84	14	3	70	12
Total	209	31(14.8%)	9(4.3%)	163(77.9%)	41(19.6%)

IV. SUMMARY AND CONCLUSIONS

Front-line soldiers (281) from the 3 regiments of a United States infantry division were examined in Korea in March 1952 for sequelae following the wearing of the new insulated rubber combat boot. Comparison was made with other standard bootgear. Subjective troop reaction to the new insulated boot was obtained.

While 147 of the 195 men who had worn the new boot felt that it increased sweating of the feet, the general subjective reaction to the boot was highly favorable.

The incidence of epidermophytosis, hyperhidrosis, maceration and erythema was significantly higher in men wearing the insulated boot than in those wearing the shoepac or the leather combat boot. Significantly higher incidence of epidermophytosis and erythema persisted even when the insulated boot had been replaced by the leather combat boot a few days prior to examination.

No effort was made to weigh the benefits of the new boot in withstanding severe wet-cold environments against the several adverse sequelae which may arise from wearing the boot under certain conditions

as described in this report.

It is emphasized that careful attention to foot hygiene, daily sock change, avoidance of prolonged, uninterrupted wearing of the boot and interdiction of the use of the boot under warmer weather conditions than those for which it was designed are essential principles in the optimal performance of the Army insulated rubber combat boot. Disregard of these principles may lead to a temporarily incapacitating foot syndrome consisting of varying degrees of tenderness and pain, erythema, hyperhidrosis and maceration. Fungus infection may be superimposed on the above or may occur as an isolated finding with an increased incidence.

Interrogation of 209 troops who had used the formula V foot powder revealed some evidence of its effectiveness in reducing sweating of the feet.

V. ADDENDUM

In addition to the data presented above, some 200 troops from other United States infantry divisions and miscellaneous Eighth Army units were interviewed at a mobile army surgical hospital concerning their general impression of the insulated boot and the use of anhidrotic foot powder. The consensus was that the new boot was more comfortable than the shoepac, that it afforded better protection against cold and that it was in general more desirable in spite of the apparent increase in foot perspiration. An occasional soldier complained that the top of the boot rubbed against his leg, but no instance of infection produced in this manner was observed. Among this same group of men, it was apparent that the use of foot powder was sporadic. The powder was not always available. Caking was a frequent complaint. Burning and an

offensive odor of the feet was an occasional complaint. There was some feeling that the new formula V powder was more effective in controlling sweating than the powder previously used.

ARMY MEDICAL RESEARCH LABORATORY

FORT KNOX, KENTUCKY

REPORT NO. 113
1 April 1953

COLD INJURY - KOREA 1951-52*

Section VIII
A STUDY OF THE PERSONALITY TRAITS
OF FROSTBITE CASUALTIES

*Subtask under Environmental Physiology, AMRL Project No. 6-64-12-028, Subtask (8K), Cold Injury Studies.

MEDICAL RESEARCH AND DEVELOPMENT BOARD
OFFICE OF THE SURGEON GENERAL
DEPARTMENT OF THE ARMY

SECTION VIII

A STUDY OF THE PERSONALITY TRAITS OF FROSTBITE CASUALTIES

by

Samuel C. Bullock
Captain,MC AUS

Luther L. Hays
Major,MSC AUS

and

Albert N. Berenberg
1st Lt.,MSC AUS

TABLE OF CONTENTS

A STUDY OF THE PERSONALITY TRAITS OF FROSTBITE CASUALTIES

I. INTRODUCTION

A psychiatric study of frostbite cases was conducted at Osaka Army Hospital, Osaka, Japan from December 1951 through April 1952. The purpose of the study as outlined by the Office of the Surgeon General was "to determine the personality patterns of personnel susceptible to cold injury in combat, and the nature and extent of affective and intellectual factors in the etiology of cold injury". The investigators also were interested in any evidence of self-inflicted cold injury. The investigation was conducted by a team composed of a psychiatrist, a clinical psychologist and a psychiatric social worker.

II. METHOD

A. Subjects

Three groups of subjects consisting of a frostbite group and two control groups were investigated.

Group I, the study group, was composed of 51 frostbite patients selected from 110 patients undergoing physiological studies in an investigation of frostbite. The criterion used in selection was that the subjects be able to take psychological tests without limitations in mobility of the arms and hands. Forty-one of the 51 subjects had sustained a "severest" injury of third or fourth degree, and 10 cases had a "severest" injury of

second degree. Forty-seven subjects had frostbite of the feet, three of the feet and hands and one of the hands exclusively.

Group II, the hospital control, was a group of 20 patients hospitalized for combat wounds other than cold injury. These men were from the same region and units as the frostbite subjects. They had been wounded on the same day or within a few days of the time the frostbite subjects received their injuries. Nineteen of these subjects were performing combat duties when injured. Gunshot, shell fragment and missile wounds of the face, neck, thorax and extremities constituted the injury in 16 subjects. Three sustained fractures in combat and one in a jeep accident. Only 20 subjects in this category could be obtained from the three army hospitals in the Osaka area.

The second control group, Group III, the combat control group, was composed of 51 subjects. This was a sample from a group of men who were subjected to the same environmental stress in time, geographical location and activity as the frostbite subjects. The individuals in the combat control group were selected from a squad, patrol or other small unit in which someone (who may or may not have been a member of the patient study group) sustained frostbite. The subjects in the combat control

group were functioning combat soldiers, without injury, on duty in Korea at the time they were studied.

The racial composition of the three groups was restricted to United States Whites and Negroes. Puerto Ricans and Hawaiians were excluded because of possible language difficulties. The frostbite study group consisted of 26 Whites and 25 Negroes. The hospital control group included 20 Whites. The combat control group included 51 Whites. All of the subjects were enlisted men with the exception of one officer in the hospital control group. Negro controls were not used in the hospital and combat groups because they could not be obtained in sufficient numbers.

B. Tests

The study and hospital control groups were investigated by the following procedures. A social history was taken, psychological tests were administered and each subject was seen in a psychiatric interview. The tests administered were the Wechsler-Bellevue Intelligence Scale (Form I), the Minnesota Multiphasic Personality Inventory (MMPI), the Structured Sentence Completion Test (SC), eight selected cards of the Thematic Apperception Test (TAT) and the Rorschach Test. The combat control group was administered the same battery of psychological tests, but only a part of the group was interviewed for a social history, and none of the group was seen for a

psychiatric interview. The study and hospital control groups were tested in a hospital in Japan, while the combat control group was tested in tents near the front lines in Korea. The social histories were taken by technicians of the Social Service Department. Psychological technicians administered the psychological tests. These workers had had hospital experience and training and were supervised by professional workers. The psychiatrist conducted each psychiatric interview.

C. Initial Organization of the Data; The Initial-Measures

The social history interview obtained a record of basic identifying and personal history data (including military history). The information was obtained in one interview. The items included in the interview are listed in Appendix I.

Each subject was seen for one psychiatric interview, approximately one hour in duration. Several subjects were seen for additional interviews and three men were transferred to the psychiatric service for treatment. The information was written as it was obtained during the interview, and it was later recorded in systematic order on a form. The form used is given in Appendix II.

The data obtained from the social history and psychiatric interviews were used as a basis for formulating a series of categories into which the data could be placed for the purpose of making quantitative comparisons

between subjects. A set of items was written for the measurement of the variable defined by each category. The measures thus formed will be referred to as interview-initial-measures. They covered the following categories:

1) Age at last birthday.
2) Education recorded by 2-year intervals.
3) History of serious illness (The duration of longest continuous illness, whether 3, 6, 12 or more months).
4) Number of accidental injuries (Accidents for which medical care was needed or from which there was some temporary incapacity. Up to six accidents were listed separately. Six or more were listed together).
5) Attitude towards illness and accidents other than cold injury (This was rated as of no concern, some concern or serious concern).
6) Reaction to cold injury (The attitude of the subject toward his removal from the front and his concern about the future consequences of his frostbite were evaluated in six steps).
7) Evidence of predisposition to cold injury (The subject's report of previous cold injury was the only datum considered as evidence).

8) Evidence of self-inflicted cold injury (Evaluated as existing with varying degrees of certainty, from none to admission of intent).

9) Attitude toward induction, broken down into several degrees of acceptance-rejection.

10) Attitude toward assignment to Korea, both at time of assignment and at time of examination.

11) Compliance with cold weather training (Reasonable precautionary measures, failure to follow instructions due to lack of equipment or other situational factors, failure to follow instructions even though equipment available and situation permitted).

12) Home background, categorized as either separation, divorce or death of parents before the subject's eighth birthday.

A clinical evaluation of each individual in the study and hospital control groups was made jointly by the psychiatrist and clinical psychologist. This evaluation was based on the social history, psychiatric interview and psychological test data. Approximately one hour was spent in studying and evaluating each case after the psychological tests had been scored.

A set of personality traits which should be evaluated, together with a scale of items for rating each, was formulated before the clinical evaluations were made.

After the clinical study of each subject, these scales of items were used to record the amount of each trait judged to be present. One scale, diagnostic category, was used only for those subjects considered to be outside the normal range of adjustment. These scales of items will hereafter be referred to as clinical-evaluation-initial-measures.

These measures covered the following traits:

1) Impulsivity: Evaluated as markedly non-impulsive, average impulsivity, fairly strongly impulsive and markedly impulsive.

2) Dependency: Rated as markedly dependent, average dependent-independent and markedly independent.

3) Long range pattern of somatic pre-occupation: Rated as absent or present to a mild or marked degree.

4) Reaction to stress: Rated from very low threshold to very strong degree of tolerance in five stages.

5) Hostility: Evaluated as normal or strong and as directed towards self or others, or towards both self and others.

6) Attitude toward father: Evaluated as unclear, acceptance or rejection.

7) Attitude toward mother: Rated the same way as No. 6.

8) Attitude toward siblings: Rated the same way as No. 6.

9) Attitude toward authority: Rated the same way as No. 6.

10) Personality adjustment evaluated as follows:

   a) Normal range of adjustment.

   b) Neurotic personality - not incapacitated by symptoms.

   c) Suggestive neurosis.

   d) Overt neurosis.

   e) Pathological personality.

   f) Latent or overt psychosis.

   g) Psychiatric disorder of an organic reaction type (Classified according to army nomenclature).

   h) Immaturity reaction.

The interview-initial-measures and the clinical-evaluation-initial-measures mentioned above were complemented by a set of test-initial-measures obtained from the scoring of the psychological tests. Each of the standard and each of the especially designed measures mentioned in the description of the tests which immediately follows, will be referred to as a test-initial-measure.

The Wechsler-Bellevue used consisted of all 11 subtests of Form I of the Wechsler-Bellevue Intelligence Scale.

The Minnesota Multiphasic Personality Inventory (MMPI) consisted of all 550 items of the inventory and was scored with the K factor added. This scoring yielded the 13 conventional T-scores (four for the validity scales and nine for the clinical scales). The T-scores for the nine clinical scales were used for making comparisons between subjects, and they were also used in obtaining three derived measures for each subject, namely: 1) Code Type (1), 2) Welsh's Anxiety Index (2) and 3) Welsh's Internalization Ratio (2). The formulae for these derived scores appear in Appendix III, Section A.

The Thematic Apperception Test (TAT) used was limited to those cards which apparently would be most likely to give indications of dependency, impulsivity and hostility in the subject, namely, the male cards 3BM, 4, 6BM, 7BM, 12M, 13MF, 14 and 17BM. The subject wrote the stories himself instead of dictating them to the examiner. All the stories produced by a given subject were studied and given a rating on each of the traits mentioned above for all the stories as a group. For each of the traits, a rating of "no data" was given in cases where the stories gave no indication as to whether

the subject did or did not possess the trait in question. When the stories did give some indication of the presence of the trait, the subject was rated as falling into one of several categories for each trait, as follows:

1) Dependency: No data, markedly dependent, average, markedly independent.
2) Impulsivity: No data, markedly non-impulsive, average, markedly impulsive.
3) Hostility: No data, average, strong towards others, strong towards the self, strong towards both others and the self.
4) Direction of Hostility: Hostility towards one of the following: females; males; authority; males and females; authority and females; authority and males; males, females and authority; generalized hostility with the object of hostility uncertain.

The sentence completion test used was Form M of the Structured Sentence Completion Test of Bertram R. Forer. This test consisted of 100 items, 54 of which were divided into sets of items. Each set dealt with a separate personality characteristic of the subject. The characteristics measured by these several sets were: attitude toward father, mother, people in general and authority (each separately); dominant drives of the subject; method of responding to aggressive acts against

himself; method of responding to failure; and the situation or person usually causing depression, anxiety, and feelings of guilt (each separately). There were five test items for each personality characteristic except drives, for which there were nine. In this study, one of the items for drives (Item No. 98 "If I were King, I would - - - -) was not used in the scoring, reducing the number of items for drives from nine to eight. Each personality characteristic was scored as being either present or absent. No attempt was made to differentiate varying amounts of the characteristic. A given characteristic was considered present if the subject's answers indicated its presence in three or more of the set of items measuring the characteristic. In the case of the drives category, this made it possible for the subject to show two different drives as there were eight items in this category. The subject answered all 100 items in the test, but only 53 items were scored and used in the study. Forty-seven items were deleted because they could not be categorized and properly evaluated as described above.

After the scores on each of the personality characteristics listed above were obtained, these scores were used in comparing subjects. They also were used to secure scores on two additional characteristics, namely:

1) over-all attitude towards authority figures (father, mother and authority, as a group) and 2) hostility.

The scoring guide used in scoring the tests was developed by the workers in the psychiatric phase of the cold injury project at Fort Knox and appears in Appendix III, Section B.

The Rorschach Test was administered and scored by the Klopfer and Kelley method. The scores for each of the Klopfer and Kelley categories were used in obtaining scores on five scales developed by the workers in the cold injury project at Fort Knox.

The five scales were developed from two factor analyses of the Rorschach carried out by Wittenborn. The first (3) analysis was based upon the Rorschach protocols of 92 Yale undergraduates and yielded four factors which Wittenborn designates as Factors I', II', III' and IV'. The second (4) was based upon the Rorschachs of 100 psychiatric patients and also yielded four factors, which he called A, B, C and D. Examination of the factor loadings, on the Rorschach scoring categories (such as W, D, Dd, M, FM, FC, etc.) in the rotated factor matrices for the two studies, indicated that three of the factors were common to both studies while one factor in each study was without a corresponding factor in the other. Factor I' of the first study was apparently the equivalent of Factor A of the second;

the factor common to both studies was therefore designated Factor I'A. Factor III' of the first study seemed to be the same as Factor B of the second; the common factor was called III'B. A third factor derived from the two studies may be labeled Factor IV'C. Factor II' of the first study and D of the second remained as two dissimilar single factors. Thus a total of five factors could appear when Rorschachs were given to subjects containing both normal and abnormal individuals. A scale for measuring each of the factors was devised as follows.

The rotated factor matrices were examined. All Rorschach scoring categories which had a factor loading of 0.300 or more in both Factor I' of the first study and Factor A of the second were selected as being measures of the common Factor I'A. Similarly, all Rorschach scoring categories with a 0.300 or greater loading in the appropriate factors in both studies were considered to be measures for Factors III'B and IV'C respectively. All those having a loading of 0.300 or more in Factor II' in the first study were selected as a measure of this factor, and those with a loading of 0.400 or more in Factor D in the second study as a measure of the latter. The higher criterion was used for Factor D because it contained a larger number of scoring categories with heavy loadings from

which to choose. After the scoring categories for each factor had been selected by the above criteria, the O and R categories were eliminated. The O's were eliminated because the Rorschachs administered in the present study were not scored for O responses. The R's were not used because R was selected in more than one factor by the above criteria, and its magnitude was so great that it might have overshadowed the effect of the other categories of response belonging to these factors. Each of the five factors was arbitrarily labeled with the name of the trait which the Rorschach theory and general psychological theory seemed to indicate to be the best descriptive title for the factor. The resulting factors with their scoring categories and names are listed below:

I'A (Sum of S, m, FC) - Negativism.

III'B (Sum of W, K, C, CF, c) - Impulsiveness.

IV'C (Sum of D, d, Dd, S, F) - Compulsiveness (Alternate title - Fluency).

II' (Sum of K, C, c, P) - Freedom from intellectual inhibitory control.

D (Sum of D, M, FM, FK, C', FC) - Intelligence or Integrative Ability.

For each subject a score was obtained for each factor by counting the total number of responses in the several scoring categories belonging to that factor.

The scores on these five factors, together with the scores on M, Sum-C, M minus Sum-C, F%, R, number of aggressive responses and chromatic minus achromatic reaction-time constituted the test-initial-measures for the Rorschach. The Rorschach patterns as a whole were considered during the clinical evaluation procedures, but individual Rorschach scoring categories other than those just mentioned were not used as test-initial-measures. All other scales cited above in connection with the various tests were used as test-initial-measures, excepting only the validity scales of the MMPI.

When the scores had been secured for all the test-initial-measures, there resulted a total of 41 scores for each subject in the combat control group (all of which were scores on test-initial-measures), and 64 scores for each subject in the study and hospital control groups (derived from all initial-measures). Some of these were scores in the true sense of the word, in that they gave the subject a number indicating his performance on the measure, e.g., I.Q.: 98. Others gave no numerical value to the response, but only placed it in a category, e.g., attitude toward father, acceptance, rejection or some other category of response. Scores of the former type were summarized for a group of subjects by determining the mean score for the group. Scores of the latter type were summarized by stating the frequency (number of

subjects) in the group of each of the several categories of response. For example, the frequencies for the various categories of response for the initial-measure attitude toward father for a group of 25 subjects might be: unclear, 5; acceptance, 16; rejection, 3; anxiety, 1. In this illustration, four frequency scores were required to represent the group's score on a single initial-measure, even though each subject gave only one response. This relationship of single scores for the individual subjects yielding multiple scores for the group was typically the case with initial-measures which involved frequency scores.

Either the mean score or the frequency of response category score(s) was obtained for each initial-measure for each of the three groups of subjects. In addition, the study group was broken down into two subgroups and the corresponding scores obtained for them. The subgroups were: Study Negro (25 cases) and Study White (26 cases). The study group was thus represented by three sets of scores, i.e., one set for the total group and two for the subgroups.

D. Final Organization of the Data; The Final-Measures

The mean and frequency scores for the various groups were next studied to determine the relationships between groups. Graphs were drawn for most of the measures and tables were made to facilitate comparisons between groups. Calculations for significance of the difference between

groups were made in typical cases until it was learned just how large a difference was required in order to approach or yield statistically significant differences. It then was possible to determine those measures which clearly and definitely showed no differences of significance between the groups compared. Many of the initial-measures were discarded from further consideration because they revealed no significant differences. Others were retained and converted into new measures by combining logically similar categories of response into a single category. For illustration, the first three categories of the clinical-evaluation-initial-measure termed personality adjustment were normal, neurotic personality and suggestive neurosis. From the data it seemed that the point in the scale at which the psychiatrist and psychologist had unconsciously made the demarcation between the normal range of adjustment and the abnormal range of adjustment was between neurotic personality and suggestive neurosis, and not at the point between normal and neurotic personality. Hence, the latter pair of categories were combined into a new category termed normal range of adjustment, and the frequency for this category was obtained by summing the frequency for the two parent categories. The new category, normal range of adjustment, was then considered a final-measure.

Two more illustrations are presented. The test-initial-measure, attitude toward father, contained the response

categories: unclear, acceptance, rejection and anxiety. Study of the data showed that acceptance was the only one of these showing any appreciable differences between groups, and also that the pattern of variation of frequencies from group to group was exactly opposite for unclear and rejection as compared to that for acceptance. It seemed clear that the category acceptance summarized the data for this measure, and the frequency for this category therefore became the frequency for the final-measure, acceptance of father, which replaced the initial-measure, attitude toward father. In some cases one initial-measure was converted into two or more final-measures. Thus the initial-test category, dominant drive, contained a large number of categories, but only two of these were answered positively an appreciable number of times by the subjects. The frequencies for these two categories became the frequencies for two final-measures, prestige drive and escape drive replacing the one initial-measure dominant drive.

The term final-measure was used to signify all these newly formulated measures and also all initial-measures which were retained unchanged and used in making the final comparisons between groups. It should be noted that in some cases (e.g. I.Q.) the initial and the final measures were one and the same. All data reported

in the body of this investigation are data on final-measures, except the data derived from the psychiatric examination.

The study of the data for the initial-measures revealed that the differences between the Study-Negro and Study-White subgroups were so great that it was not justifiable to compare the total study group composed of the mixture of these two with the control groups which were composed entirely of Whites. For this reason, no comparisons were made between the total study group and others using the final-measures. Instead, the designation Group 1 was reassigned to the Study-White group, and the Study-Negro group was called Group 1N. The only comparisons made with the final-measures were: Study-Negro with Study-White, Study-White with each of the control groups and the two control groups with each other. The statistical significance of the differences obtained for each of these comparisons for each of the final-measures was calculated by chi square, the "t" test or the direct calculation of probability, whichever was appropriate.

III. RESULTS

Mean or frequency scores for each group of subjects are given on the initial-measures in Appendix IV. A few initial-measures were omitted because the number of answers was so meager as to yield practically no data. Appendix IV also

contains means for each group on each of the subtests of the W chsler-Bellevue and on each of the Rorschach scoring categories.

Data on the final-measures showing differences between two or more groups of subjects which were significant at the 1% and 5% level of confidence are given in Tables 1, 2 and 3. Included in the tables are comparisons of measures which yielded only a 5.1 to 20% level of confidence and could only be considered as suggestive trends or differences. Every final-measure involving frequency scores basically possesses only one response category, namely a particular response or characteristic of the subject. This may be considered as two categories, namely, 1) presence and 2) absence of the response or characteristic. The data for such measures are presented by stating the number and percent of subjects in a given group who fall in the presence category, i.e., have the response or characteristic. Data on these measures are given in Tables 1 and 2. Data on final-measures involving mean scores are given in Table 3. The results of the psychiatric examination of the patients and hospital controls are shown in Table 4.

The positive results together with their sources are summarized as follows:

1. At the 1% level of confidence
   a. More of the hospital controls than the combat controls exhibited drive for prestige, achievement and dominance as their strongest attributes (sentence completion test).

TABLE 1

INTERVIEW-FINAL-MEASURES AND CLINICAL-EVALUATION-FINAL-MEASURES. NUMBER AND PERCENTAGE OF SUBJECTS IN THE STUDY NEGRO, STUDY WHITE AND HOSPITAL CONTROL GROUPS FALLING IN THE PRESENT CATEGORY OF EACH MEASURE, TOGETHER WITH DIFFERENCES BETWEEN THE PERCENTAGES IN THE GROUPS

Type of Final-Measure	Present Category of Final-Measure	Number of Cases Falling in Present Category			% of Cases Falling in Present Category			Difference in Percentage *	
		Group 1N Study Negro (N=25)	Group 1 Study White (N=26)	Group 2 Hosp. White (N=20)	Group 1N Study Negro	Group 1 Study White	Group 2 Hosp. White	Study White MINUS Study Negro	Study White MINUS Hosp. White
Interview	[illegible] one or more accidents	14	19	10	56	76	50	20c	26c
	Shows no concern over accidents or injuries other than cold injury	12	13	4	50	50	20	0	30c
	Reports previous cold injury one or [illegible]	6	2	2	25	8	10	-17c	-2
	Took reasonable precautions against cold injury	11	7	14	46	30	82	-16	-52a
	Failed to take precautions against cold injury, though nothing hindered	6	7	0	25	30	0	5	30b
	[illegible]	9	15	12	36	58	60	22c	-2
	Reports parents separated before his eighth birthday	7	5	1	28	19	5	-9	14c
Clinical Evaluation	[illegible]	12	6	9	48	23	45	-25c	-22c
	[illegible] assistance	10	20	15	40	77	75	37b	2
	[illegible]	13	19	13	52	73	65	21c	8
	[illegible]	8	15	15	32	58	75	26c	-17
	Diagnosis: [illegible] reaction ([illegible])	8	6	1	32	23	5	-9	18c
	Normal amount of hostility	5	4	7	21	15	35	-6	-20c
	Strong hostility towards others	17	19	10	71	73	50	2	23c
	Persistence of childhood neurotic traits beyond 6 years of age	14	14	6	61	54	30	-7	24c
	Low or very low tolerance of stress	20	14	11	80	54	55	-26c	-1

See Explanatory Notes - following page

Explanatory Notes: Table 1

* The letters accompanying differences indicate the Level of Confidence at which the difference is statistically significant, as follows:

a - 1% or less
b - 1.1% to 5%
c - 5.1% to 20%
No letter - Greater than 20%

Only those differences followed by "a" or "b" are conventionally considered statistically significant. Significance was calculated by the chi square test, corrected for continuity, using the actual frequencies (not the percentages), or by the direct method when cell frequencies were too small to justify use of chi square.

TABLE 2

TEST FINAL-MEASURES. NUMBER AND PERCENTAGE OF SUBJECTS IN EACH GROUP FALLING IN THE PRESENT CATEGORY OF EACH MEASURE, TOGETHER WITH DIFFERENCES BETWEEN THE PERCENTAGES OF THE GROUPS

Present Category of Final-Measure	Number of Cases Falling in Present Category: Group 1N Study Negro (N-25)	Group 1 Study White (N-26)	Group 2 Hosp. White (N-20)	Group 3 Combat White (N-51)	% of Cases Falling in Present Category: Group 1N Study Negro	Group 1 Study White	Group 2 Hosp. White	Group 3 Combat White	Difference in Percentage *: Study White MINUS Study Negro	Study White MINUS Hosp. White	Study White MINUS Combat White	Hosp. White MINUS Combat White
Strongest drive: [illegible], SC	4	5	11	8	16	19	55	16	3	-36b	3	39a
Strongest drive: [illegible], SC	4	3	1	3	16	12	5	26	-4	7	-14	-21c
Attitude toward father: acceptance, SC	15	20	17	34	60	77	85	68	17	-8	9	17c
Attitude toward mother: acceptance, SC	17	22	14	45	63	85	70	88	17	15	-3	-18c
Cause of depression not clear, SC	22	23	13	36	88	59	65	71	1	24c	18c	-6
Guilt feelings caused by harming others, SC	5	2	5	6	20	8	25	12	-12	-17c	-4	13
Reaction to aggression: not clear, SC	11	15	5	26	44	58	25	51	14	33c	7	-26c
Reaction to aggression: acceptance, SC	2	3	6	10	8	12	30	20	4	-18c	-8	10
Reaction to aggression: passive emotional reaction, SC	10	5	7	14	40	19	35	27	-21c	-16	-8	8
Reaction to aggression: restriving, SC	0	4	2	9	0	15	10	18	15c	5	-3	-8
Strong hostility toward self and others, TAT	9	17	11	30	38	68	55	59	30c	13	9	-4
Markedly impulsive, TAT	6	8	4	7	26	31	20	14	5	11	17c	6
Rorschach chromatic minus achromatic reaction time: 10 or more seconds	3	8	7	17	12	31	35	33	19c	-4	-2	2

See Explanatory Notes - following page

Explanatory Notes: Table 2

* The letters "a", "b" and "c" following the differences indicate the Level of Confidence at which the differences are statistically significant, as follows:

a - 1% or less
b - 1.1% to 5%
c - 5.1% to 20%
No letter - Greater than 20%

Only those differences followed by "a" or "b" are conventionally considered statistically significant. Significance was calculated by the chi square test, corrected for continuity, using the actual frequencies (not the percentages), or by the direct method in cases where cell frequencies were too small to justify use of chi square.

TABLE 3

FINAL-MEASURES WHICH WERE SCORED QUANTITATIVELY RATHER THAN BY CATEGORIES OF PRESENT OR ABSENT.
MEANS AND STANDARD DEVIATIONS OF EACH GROUP OF SUBJECTS TOGETHER WITH DIFFERENCES BETWEEN MEANS OF GROUPS

FINAL-MEASURES	Group 1N Study Negro		Group 1 Study White		Group 2 Hosp. White		Group 3 Combat White		DIFFERENCE BETWEEN MEANS			
	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Study White MINUS Study Negro	Study White MINUS Hosp. White	Study White MINUS Combat White	Hosp. White MINUS Combat White
Age in years, last birthday	21.0	1.6	[illegible]	[illegible]	[illegible]	[illegible]	21.8	1.8	1.7c	1.0	0.9	-0.1
Schooling, years of [illegible]	9.5	[illegible]	9.7	2.0	[illegible]	[illegible]	10.1	2.3	0.1	-0.4	-0.4	0.0
Full-Scale I.Q. Wechsler-Bellevue	81.6	[illegible]	[illegible]	14.7	97.6	14.1	97.9	13.1	14.9a	-1.1	-1.4	-0.3
Verbal I.Q. Wechsler-Bellevue	82.7	10.8	[illegible]	[illegible]	[illegible]	13.5	[illegible]	14.9	9.7c	-2.4	-3.7	-1.3
Performance I.Q. Wechsler-Bellevue	[illegible]	[illegible]	[illegible]	16.9	[illegible]	15.2	[illegible]	12.5	14.9a	-2.9	-2.5	+0.4
Negativism, T-Score Rorschach Factor II'	55.3	17.7	55.0	9.8	49.5	10.5	49.5	9.5	-1.8	5.5c	5.5b	0.0
Impulsiveness, T-Score Rorschach Factor [illegible]	54.2	17.4	52.1	10.9	53.3	7.3	49.7	9.6	-2.1	-1.2	2.4	3.6c
Compulsiveness, T-Score Rorschach Factor [illegible]	46.2	9.6	[illegible]	10.1	48.9	9.5	50.2	10.1	3.7	1.0	-0.3	-1.3
Freedom from control, T-Score Rorschach Factor II'	43.9	9.9	48.7	9.5	52.0	14.1	50.4	10.9	4.8c	-3.3	-1.7	1.6
Integrative ability, T-Score Rorschach Factor D	48.4	21.1	48.0	10.5	46.8	10.4	50.9	10.4	-0.4	1.2	-2.9	-4.1
Number of responses on Rorschach, T-Score	50.8	22.0	50.5	15.4	48.9	10.5	50.0	10.7	0.3	1.6	0.5	-1.1
Number of aggressive responses on Rorschach, Raw Score	1.6	2.3	0.8	0.9	0.9	1.2	0.9	1.1	-0.8c	-0.1	-0.1	0.0
M minus Sum-C on Rorschach, T-Score	50.3	7.2	52.7	14.5	49.4	9.2	49.9	9.2	2.4	3.3	2.8	-0.5
Anxiety Index MMPI, (Raw Score)	63.7	18.2	54.3	17.2	58.3	15.9	56.3	15.3	-9.4b	-4.0	-2.0	2.0
Internalization Ratio MMPI, (Raw Score)	1.05	0.11	1.01	0.12	1.00	0.12	0.98	0.12	-.04c	.01	.03	.02
Hypochondriasis Scale MMPI, T-Score of MMPI	67.3	10.1	60.6	12.8	56.0	6.5	54.0	11.1	-6.7c	4.6c	6.6b	2.0

See Explanatory Notes - following page

Explanatory Notes: Table 3

A. T-Scores for the hypochondriasis scale are T-Scores obtained from the MMPI manual and are therefore based on the distribution of scores in the standardization populations of the authors of the MMPI. All other T-Scores mentioned are based upon the distribution of scores in the combat White control group.

B. Due to the discard of MMPI tests shown to be invalid by the validity scales, the numbers of cases upon which the means for MMPI data (last three rows) are based is less than for other data, and are as follows:

Group 1N - 15
Group 1 - 25
Group 2 - 18
Group 3 - 50

C. The letters "a", "b" and "c" following some figures for difference between means indicates the Level of Confidence at which the difference is statistically significant, as follows:

a - 1% or less
b - 1.1% to 5%
c - 5.1% to 20%
No letter - Greater than 20%

Only those differences followed by either "a" or "b" are conventionally considered statistically significant.

TABLE 4

**DIAGNOSTIC CATEGORY: ARMY CLASSIFICATION CODE NUMBER
(Clinical-Evaluation-Initial-Measure)
Number of cases in Group 1N, 1 and 2 falling
in each category listed below**

Group	Army Code No.	1N Study Negro	1 Study White	2 Hosp. White
Total No. Cases		25	26	20
Normal	0000	10	16	16
Schizophrenic reaction simple type	3000	0	1	0
Schizophrenic reaction latent	3005	1	0	0
Anxiety reaction	3100	1	0	1
Neurotic depressive reaction	3140	2	0	1
Schizoid personality	3200	3	1	1
Emotional instability reaction	3210	1	2	0
Passive dependency reaction	3211		1	1
Passive aggressive reaction	3212	3	3	0
Mental disorder with structural change in brain	3041	0	2	0

b. More of the hospital controls than the White frostbite group took reasonable precautions against cold injury (interview).

c. The White frostbite groups showed higher full-scale and performance IQs than did the Negro frostbite group (Wechsler-Bellevue).

2. At the 5% level of confidence

a. More hospital controls than White frostbite cases exhibited drive for prestige,

achievement and dominance as their strongest att ibutes (sentence completion test).

b. Fewer of the White frostbite cases than the hospital controls took adequate precautionary measures against cold injury when circumstances permitted such steps (interview).

c. The White frostbite group was more negativistic on the Rorschach test than were the combat controls.

d. The White frostbite group scored higher on the Hypochondriasis scale of the Minnesota Multiphasic Personality Inventory than did the combat controls.

e. The "father reaction" of the White frostbite group was more strongly one of acceptance than was the reaction of the Negro frostbite group.

f. The Negro frostbite group showed a higher anxiety index on the MMPI than did the White frostbite group.

3. At a "suggestive level" utilizing the range of 5.1 to 20% level of confidence

a. The combat controls when compared to the hospital con[illegible]ls showed:

1) Stronger escape tendencies as their dominant drive (sentence completion test).

2) Lesser degree of acceptance of father (sentence completion test).

3) A greater acceptance of mother (sentence completion test).

4) Less tendencies of impulsiveness (Rorschach).

b. The White frostbite group when compared with the hospital controls showed:

1) A tendency to have a frequent history of one or more moderately severe accidents (interview).

2) Less concern over illnesses and accidents other than frostbite (interview).

3) A more common element of home background of separation of the parents before the patient's eighth birthday (interview).

4) Less marked dependency (clinical evaluation).

5) More frequently diagnosed in the category of immaturity reaction (clinical evaluation).

6) Persistence of childhood neurotic traits (e.g., nail-biting, enuresis) beyond the age of 6 years (clinical evaluation).

7) Less frequent guilt feeling due to having harmed others (sentence completion test).

8) Fewer cases tended to react to aggression by acceptance (sentence completion test).

9) More negativistic tendencies (Rorschach).

10) A greater tendency to be hypochondriacal (MMPI).

c. The White frostbite group when compared with the combat controls tended to be more markedly impulsive (Thematic Apperception Test).

d. The White frostbite group when compared with the Negro frostbite group showed:

1) A more frequent history of one or more moderately severe accidents (interview).

2) Fewer previous histories of cold injuries (interview).

3) A less frequent history of separation of parents before patients's eighth birthday as an element of home background (interview).

4) Less marked dependency (clinical evaluation).

5) A tendency to fall more often in the normal range of adjustment (clinical evaluation).

6) A tendency to be more accepting of the mother (clinical evaluation).

7) A tendency to have a higher tolerance to stress (clinical evaluation).

8) A tendency less frequently to meet aggression with a passive emotional reaction (sentence completion test).

9) A tendency to react more often to failure by restriving (sentence completion test).

10) A tendency to display stronger hostility toward self and others (Thematic Apperception Test).

11) A tendency to have a higher Wechsler-Bellevue verbal I.Q.

12) A tendency to show a greater freedom from intellectual inhibitory control (Rorschach).

13) A tendency to give fewer aggressive responses on the Rorschach Test.

14) A tendency to have a lower internalization ratio on the MMPI.

15) A tendency to be less hypochondriacal according to the MMPI.

It must be emphasized that the traits and characteristics cited above are safely used only when the measuring instrument is also mentioned. Their use as a clinical description is warranted only insofar as the instrument is a valid tool of clinical evaluation in the trait named. For instance, the term "more hypochondriacal according to the MMPI" means no more than the subject scored higher on the hypochondriasis scale of the MMPI, and not necessarily that he displayed any clinical evidence of hypochondriasis.

IV. DISCUSSION AND CONCLUSIONS

From a purely statistical viewpoint it is desirable that the comparison groups be as large as possible. The principal advantage of increased group size is that group statistics and, consequently, comparison statistics, become more reliable. For this reason it would be highly desirable to be able, legitimately, to consider all of the frostbite cases as a single group on one hand, and all of the controls as a single group on the other.

Whether or not such a combining procedure is acceptable depends primarily on the respective subgroups (White frostbite, Negro frostbite, combat controls and hospital controls) being essentially homogeneous with respect to the measured variables when combined. An examination of the results casts serious doubt on the validity of this process for aggrandizing the sample size. For instance, there were significant differences between the two frostbite subgroups in such variables as full-scale and performance IQs, in reactions toward father and in the anxiety index of the MPI. The two control subgroups likewise showed a difference, i.e., in dominant drive.

Furthermore, since larger sample sizes will disclose more readily significant differences between groups, scientific rigor demands that evidence opposing the enlarging of the sample by combining subgroups be most stringently applied. In this light one must consider the suggestive results mentioned in the last section as strong reason for not combining. The individual subgroups were kept separate for this reason, and they were considered as major groups.

Since it was felt that combining Negro frostbite with White frostbite cases was not allowable, there seemed to be little justification for comparing Negro frostbite with White controls. Consequently, comparisons across the frostbite variable were only between White groups.

As might be expected the frostbite group (only White subjects) utilized fewer precautions against cold injury than did the hospital

controls. This was not conclusive evidence of willful intent or self-infliction on the part of the frostbite patient. Unfortunately there was no comparable information available on the combat White control subjects.

The hospital controls as a group gave evidence of a strong drive for such attributes as prestige, achievement and dominance which lead to respect or admiration from others. By contrast the frostbite group showed no one single dominating drive, indicating either their greater heterogeneity in this respect or a general asthenia in the drive mechanism.

When compared with the combat controls, the frostbite group showed a higher average score on the Rorschach factor labelled in this report as negativism. Negativism, in the general meaning of the term, refers to one's tendency to oppose by thought or action any effort on another's part to influence one's behavior. Quite obviously such a trait would seriously penalize any training and indoctrination program, for the stronger the psychological pressure brought to bear by such a program, the stronger the opposition that it would meet. It was interesting to note that while not significant at an acceptable level, the frostbite group also scored higher than the hospital controls with respect to this factor.

Finally, the frostbite group scored higher than did the combat controls on the hypochondriasis scale of the MMPI. This was interpreted either as indicating a non-neurotic concern with a real injury (frostbite), or as transcending the real injury

and being a reflection from some facet of the basic personality. A comparison of the hospital controls (who had approximately as much reason to be concerned with real injuries as did the frostbite group) with the combat controls showed very little difference between these two groups on the hypochonuriasis score. This would tend to show that the frostbite group's high score in this variable was more characteristic of the personalities of the group rather than of the injury.

These were the findings that were statistically significant. Other results, called suggestive in the last section, should not be completely ignored, but should be read into the picture with extreme caution and due recognition of the speculative nature of any picture so developed.

From the statistically significant results obtained in this study one can draw no picture of a cold injury personality. In fact, the study, as it was planned and executed provided no basis for differentiating between effects on the personality as the result of cold injury on one hand, and personality traits predisposing to cold injury, on the other. Therefore, it would appear that certain traits seem to characterize the group of men who were frostbitten in contradistinction to the two different controls.

V. RECOMMENDATIONS

Future field studies of this nature should determine the following:

1. Whether the significant results obtained in this study are true psychological measures and not artifacts of the testing procedure.
2. That the suggestive findings be investigated further, even to designing instruments for the purpose of uncovering and measuring them specifically.

APPENDIX I

Categories of Information Collected in Social History Interview

1. Name
2. Medical diagnosis (if subject is a patient)
3. Organization
4. Rank
5. Army Component
6. Age
7. Race
8. Religion
9. MOS
10. Marital status
11. State of residence
12. Months of service prior to cold injury
13. Time overseas prior to cold injury
14. Days of exposure prior to injury
15. Type of action at time of exposure (combat or noncombat, specific activity recorded)
16. Equipment worn on feet
17. History of previous cold injury or circulatory difficulties
18. Degree of adjustment to military life
19. Military offenses
20. Time spent out of doors in relation to job and hobby
21. Education
22. School adjustment
23. Reason for leaving school
24. Work history
25. Medical history
26. Position in family constellation
27. Home environment
28. Age of subject at time of separation, divorce, or death of parent
29. Dominant personality in the home
30. Civilian offenses

APPENDIX II

Form Used For Recording Psychiatric Interview Data

A. Identifying Information

1. Age 2. Rank 3. Race 4. Marital status
5. Unit
6. Length of service prior to injury
7. Time in Korea
8. Method of induction

B. Method of Injury

1. Duties at time
2. Time exposed to cold
3. Weather conditions
4. Dress
5. Precautions
    a. Individual
    b. Unit basis
    c. Opinion of precautions
6. Evidence of predisposition to cold injury
7. Evidence of self-infliction
8. Attitude toward frostbite
9. Method of relating information

C. Morale

1. Unit morale
2. Individual's morale
3. Military disciplinary record

APPENDIX II (cont.)

Pre-Service History

A. Family History

1. Broken home before 16 years
    a. Reason
    b. Substitute parents
2. Parental attitudes
    a. Mother
    b. Father
3. Parental discipline
4. Attitude toward parents
5. Position in family
6. Relation with siblings

B. Pre-service Personality and Adjustment

1. General
    a. Health
    b. Childhood neurotic traits
2. Geographical area
3. Accidental injuries
4. School adjustment
    a. Grades finished
    b. Interests
    c. Relations with students and teachers
5. Work adjustment
    a. Number of jobs
    b. Reason for leaving
6. Civilian court record
7. Marital adjustment
8. Sexual adjustment
9. Emotional reactions
    a. Disposition
    b. Aggression
    c. Handling of decisions
    d. Reaction to stress
10. Plans for future

C. Vasomotor Responses

1. Sweating
    a. Hands
    b. Feet

APPENDIX II (cont.)

D. Mental Status Examination

1. Manner
2. Speech
3. Emotional responses
4. Additional notes

E. Diagnostic Impression

APPENDIX III

SECTION A. Formulae for Determining Scores Derived from the Minnesota Multiphasic Personality Inventory

1. Procedure for Determining Code Type

   a) Assign a number to each of the clinical scales as follows:

Hs - 1	Pd - 4	Pt - 7
D - 2	Mf - 5	Sc - 8
Hy - 3	Pa - 6	Ma - 9

   b) Arrange the subject's T-scores on the nine clinical scales in rank order according to magnitude beginning with the highest score. List them by their numerical equivalents as given in "a" above.

   c) When this has been done, the first two figures of the resulting arrangement of numbers constitute the code type provided the T-scores on the scales represented by these two figures are both 54 or greater. If either or both of them are less than 54, the subject has no code type.

2. The Formula for Welsh's Anxiety Index is:

$$\frac{Hs + D + Hy}{3} + (D + Pt) - (Hs + Hy)$$

in which the designations for the various scales represent the T-scores of the subject on the respective scales.

3. The Formula for Welsh's Internalization Ratio is:

$$\frac{Hs + D + Pt}{Hy + Pa + Ma}$$

in which the designations for the various scales represent the T-scores of the subject on the respective scales.

APPENDIX III (cont.)

SECTION B. Sentence Completion Scoring Guide (Numbers in parenthesis are the numbers of the sentences in the test which are used for measuring the characteristic named).

I

DRIVES

(2, 7, 17, 29, 37, 52, 74, 83)

a. Omission
b. Unclear
c. Passive dependence - - - being supported by another
d. Love affiliation - - - - to be with or be loved by another, or to be socially accepted; not involving sex or sex object
e. Prestige, achievement, dominance - - - - - - performance or position leading to respect or admiration from others or acceptance of one's authority by others
f. Health - - - - - - - - - for health or physical well being
g. Escape - - - - - - - - - conscious or unconscious flight from environment or situations (not persons)
h. Independence - - - - - - freedom of control or support by others
i. Economic - - - - - - - - wealth, money, income
j. Sex - - - - - - - - - - sexual contact or gratification, or affiliation with love object

II

INTERPERSONAL FIGURES

Attitude toward father:	(9, 16, 33, 70, 88)
Attitude toward mother:	(20, 35, 60, 76, 94)
Attitude toward people:	(15, 38, 49, 66, 84)
Attitude toward authority:	(23, 36, 73, 77, 91)

a. Omission
b. Unclear
c. Rejection, hostility - - active or passive
d. Acceptance, compliance - - love, dependency, security
e. Anxiety, fear, insecurity

APPENDIX III (cont.)

III

DEPRESSION - ANXIETY

Causes of depression: (12, 45, 64, 97, 100)
Causes of anxiety: (8, 47, 56, 79, 87)

a. Omission
b. Unclear
c. Failure or lack of achievement
d. Loss of love or rejection by love objects, including sex
e. Social disapproval
f. Health - - - - - - - - - - - - - including physical injury, hospitalization or sickness. (For anxiety scale, code under "h" if an object is mentioned and the injury is not mentioned; code here if specific injury or sickness is mentioned.)
g. Loss of independence
h. For anxiety scale - - - - - - physical objects, real or imaginary; physical states (outside the body, such as darkness). Anything toward which a phobia could be developed.
i. For depression scale - - - - - guilt, when none of the above

IV

SOURCE OF GUILT

(4, 24, 43, 54, 69)

a. Omission
b. Unclear
c. Authority figures
d. Others
e. Self

V

REACTION TO AGGRESSION

(22, 42, 51, 72, 80)

a. Omission
b. Unclear

APPENDIX III (cont.)

c. Acceptance
d. Counterattack
e. Escape
f. Passive emotional reaction - - - crying, feeling of rejection

VI

REACTION TO FAILURE

(3, 25, 41, 48, 63)

a. Omission
b. Unclear
c. Acceptance - - - - - - - - - - - - without re-striving or noticeable mood change
d. Agression or hostility - - - - - with or without re-striving of mood change
e. Re-striving - - - - - - - - - - - without aggression
f. Negative mood change not included in the above - including guilt, anxiety, depression, etc.

APPENDIX IV

TABLES SHOWING THE FREQUENCIES OF EACH RESPONSE CATEGORY FOR THE INITIAL-MEASURES AND THE MMPI WECHSLER-BELLEVUE AND RORSCHACH SCORES

TABLE OF CONTENTS

Table

TABLE OF CONTENTS (Cont.)

TABLE I

HISTORY OF SERIOUS ILLNESSES (Interview-Initial-Measure)
Number of cases in Group 1N, 1, and 2 falling
in each category listed below

Group	1N Study Negro	1 Study White	2 Hosp. White
Total No. Cases	25	26	20
No data	0	1	1
Illness of 1-3 months	6	5	2
Illness of 4-6 "	1	0	1
Illness of 6-12 "	0	2	2
Illness over 12 "	0	2	0
No Illness	18	16	14

TABLE 2

HISTORY OF NUMBER OF ACCIDENTS (Interview-Initial-Measure)
Number of cases in Group 1N, 1, and 2 falling
in each category listed below

	1N Study Negro	1 Study White	2 Hosp. White
Total No. Cases	25	26	20
No data	0	1	0
One accident	8	5	4
Two accidents	3	10	2
Three accidents	2	1	2
Four accidents	1	2	1
Five accidents	0	0	0
Six or more accidents	0	1	1
No accidents	11	6	10

TABLE 3

ATTITUDE TOWARD ILLNESS AND/OR ACCIDENTS OTHER THAN COLD INJURY (Interview-Initial-Measure)
Number of cases in Group 1N, 1, and 2 falling in each category listed below

Group	1N Study Negro	1 Study White	2 Hosp. White
Total No. Cases	25	26	20
No data	1	0	0
No concern	12	13	4
Some concern	12	12	13
Serious concern	0	1	3

TABLE 4

REACTION TO COLD INJURY (Interview-Initial-Measure)
Number of cases in Group 1N, 1, and 2 falling in each category listed below

Group	1N Study Negro	1 Study White	2 Hosp. White
Total No. Cases	25	26	20
No data	3	4	20
Relief at removal from front without concern of future consequences	7	12	0
Relief at removal from front with concern about future consequences	1	2	0
No expression of relief, and no concern over future consequences	12	7	0
No expression of relief, with concern over future consequences (without resentment)	1	1	0
Strong resentment over frostbite with concern over future consequences	1	0	0
Strong resentment without concern over future consequences	0	0	0

TABLE 5

EVIDENCE OF PREDISPOSITION TO COLD INJURY (Interview-Initial-Measure)
Number of cases in Group 1N, 1, and 2 falling
in each category listed below

Group	1N Study Negro	1 Study White	2 Hosp. White
Total No. Cases	25	26	20
No data	1	0	0
None	18	24	18
Previous cold injury one or more times	6	2	2

TABLE 6

EVIDENCE OF SELF-INFLICTED COLD INJURY (Interview-Initial-Measure)
Number of cases in Group 1N, 1, and 2 falling
in each category listed below

Group	1N Study Negro	1 Study White	2 Hosp. White
Total No. Cases	25	26	20
No data	0	C	0
None	24	25	20
Suggestive	1	1	0
Possibility suspected	0	0	0
Definite indications	0	0	0
Admissions of intent	0	0	0

TABLE 7

REACTION TO STRESS (Clinical-Evaluation-Initial-Measure)
Number of cases in Group 1N, 1, and 2 falling
in each category listed below

Group	1N Study Negro	1 Study White	2 Hosp. White
Total No. Cases	25	26	20
No data	0	0	0
Very low threshold tolerance	3	2	2
Low tolerance; avoidance of stress	17	12	9
Moderate degree of tolerance	5	11	8
Strong degree of tolerance	0	1	0
Very strong degree of tolerance	0	0	1

TABLE 8

ATTITUDE TOWARD INDUCTION (Interview-Initial-Measure)
Number of cases in Group 1N, 1, and 2 falling
in each category listed below

Group	1N Study Negro	1 Study White	2 Hosp. White
Total No. Cases	25	26	20
No data	0	0	0
Negative; No statement that it was fair	3	4	1
Acceptance (but still negative); with statement - it was fair	11	8	8
Positive acceptance	3	3	2
Volunteered for opportunity or as career	4	8	6
Volunteered as flight or escape	4	3	3
None of the above	0	0	0

TABLE 9

ATTITUDE TOWARD ASSIGMENT TO KOREA (Interview-Initial-Measure)
Number of cases in Group 1N, 1, and 2 falling
in each category listed below

Group	1N Study Negro	1 Study White	2 Hosp. White
Total No. Cases	25	26	20
No data	0	1	0
Good now, initial acceptance	6	9	6
Good now, initial rejection	2	1	4
Fair now, initial acceptance	8	8	7
Fair now, initial rejection	5	3	1
Poor now, initial acceptance	2	2	1
Poor now, initial rejection	2	2	1

TABLE 10

COMPLIANCE WITH COLD WEATHER TRAINING (Interview-Initial-Measure)
Number of cases in Group 1N, 1, and 2 falling
in each category listed below

Group	1N Study Negro	1 Study White	2 Hosp. White
Total No. Cases	25	26	20
No data	1	3	3
Reasonable precautionary measures	11	7	14
Failure to follow instructions due to lack of equipment or the like	7	9	3
Failure to follow instructions even though equipment available and nothing hindered	6	7	0

TABLE 11

HOME BACKGROUND (Interview-Initial-Measure)
Number of cases in Group 1N, 1, and 2 falling in each category listed below

Group	1N Study Negro	1 Study White	2 Hosp. White
Total No. Cases	25	26	20
No data	0	0	0
Parents never separated	9	15	12
Parents separated before subject 16 years of age	14	7	4
Parents separated after subject 16 years of age	2	4	4

TABLE 12

IMPULSIVITY (Clinical-Evaluation-Initial-Measure)
Number of cases in Group 1N, 1, and 2 falling in each category listed below

Group	1N Study Negro	1 Study White	2 Hosp. White
Total No. Cases	25	26	20
No data	0	0	0
Markedly nonimpulsive	3	0	3
Average impulsivity	8	9	6
Fairly strongly impulsive	10	13	7
Markedly impulsive	4	4	4

TABLE 13

DEPENDENCY (Clinical-Evaluation-Initial-Measure)
Number of cases in Group 1N, 1, and 2 falling
in each category listed below

Group	1N Study Negro	1 Study White	2 Hosp. White
Total No. Cases	25	26	20
No data	0	0	0
Markedly dependent	12	6	9
Average dependent-independent	13	18	10
Markedly independent	0	2	1

TABLE 14

LONG RANGE PATTERN OF SOMATIC PREOCCUPATION
(Clinical-Evaluation-Initial-Measure)
Number of cases in Group 1N, 1, and 2 falling
in each category listed below

Group	1N Study Negro	1 Study White	2 Hosp. White
Total No. Cases	25	26	20
No data	0	0	0
Absent	19	21	16
To mild degree	4	3	2
To marked degree	2	2	2

TABLE 15

ATTITUDE TOWARD FATHER (Clinical-Evaluation-Initial-Measure)
Number of cases in Group 1N, 1, and 2 falling
in each category listed below

Group	1N Study Negro	1 Study White	2 Hosp. White
Total No. Cases	25	26	20
No data	0	0	0
Unclear	1	1	1
Rejection hostility (active or passive)	14	5	4
Acceptance	10	20	15
Anxiety	0	0	0

TABLE 16

ATTITUDE TOWARD MOTHER (Clinical-Evaluation-Initial-Measure)
Number of cases in Group 1N, 1, and 2 falling
in each category listed below

Group	1N Study Negro	1 Study White	2 Hosp. White
Total No. Cases	25	26	20
No data	0	0	0
Unclear	3	0	0
Rejection hostility (active or passive)	9	7	7
Acceptance	13	19	13
Anxiety	0	0	0

TABLE 17

ATTITUDE TOWARD SIBLINGS (Clinical-Evaluation-Initial-Measure)
Number of cases in Group 1N, 1, and 2 falling
in each category listed below

Group	1N Study Negro	1 Study White	2 Hosp. White
Total No. Cases	25	26	20
No data	0	0	0
Unclear	20	24	13
Rejection hostility (active or passive	4	1	2
Acceptance	1	1	5
Anxiety	0	0	0

TABLE 18

ATTITUDE TOWARD AUTHORITY (Clinical-Evaluation-Initial-Measure)
Number of cases in Group 1N, 1, and 2 falling
in each category listed below

Group	1N Study Negro	1 Study White	2 Hosp. White
Total No. Cases	25	26	20
No data	0	0	0
Unclear	7	5	3
Rejection hostility (active or passive)	13	12	7
Acceptance	5	9	10
Anxiety	0	0	0

TABLE 19

PERSONALITY ADJUSTMENT (Clinical-Evaluation-Initial-Measure)
Number of cases in Group 1N, 1, and 2 falling
in each category listed below

Group	1N Study Negro	1 Study White	2 Hosp. White
Total No. Cases	25	26	20
No data	0	0	0
Normal	5	13	8
Neurotic personality	3	2	7
Suggested neurosis within the normal range of adjustment	2	1	1
Overt neurosis	3	0	2
Pathological personality	3	1	1
Latent or overt psychosis	1	1	0
Psychiatric disorder of an organic reaction type	0	2	0
Immaturity reaction	8	6	1

TABLE 20

DIAGNOSTIC CATEGORY; ARMY CLASSIFICATION CODE NUMBER
(Clinical-Evaluation-Initial-Measure)
Number of cases in Group 1N, 1, and 2 falling
in each category listed below

Group	Army Code No.	1N Study Negro	1 Study White	2 Hosp. White
Total No. Cases		25	26	20
Normal	0000	10	16	16
Schizophrenic reaction simple type	3000	0	1	0
Schizophrenic reaction latent	3005	1	0	0
Anxiety reaction	3100	1	0	1
Neurotic depressive reaction	3140	2	0	1
Schizoid personality	3200	3	1	1
Emotional instability reaction	3210	1	2	0
Passive dependency reaction	3211	4	1	1
Passive aggressive reaction	3212	3	3	0
Mental disorder with structural change in brain	3041	0	2	0

TABLE 21

HOSTILITY (Clinical-Evaluation-Initial-Measure)
Number of cases in Group 1N, 1, and 2 falling in each category listed below

Group	1N Study Negro	1 Study White	2 Hosp. White
Total No. Cases	25	26	20
No data	1	0	0
Normal	5	4	7
Strong toward others	10	17	6
Strong toward self	2	3	3
Strong toward others and self	7	2	4

TABLE 22

MEAN SCORES ON THE WECHSLER-BELLVUE INTELLIGENCE SCALE – FORM I (Test-Initial-Measure)

Group	1N Study Negro	1 Study White	2 Hosp. White	3 Comb. White
Full scale IQ (based on 11 sub tests)	81.56	96.50	97.60	97.94
Verbal scale IQ (based on 6 sub tests)	82.72	92.38	94.80	96.10
Performance scale IQ	83.16	93.12	101.00	100.55
Full scale weighted score	72.2	92.1	94.8	95.4
Verbal weighted score	33.2	43.4	43.1	44.2
Performance weighted score	39.0	48.7	51.8	51.3
Information weighted score	6.7	9.0	9.5	8.9
Comprehension weighted score	7.4	10.4	9.6	10.2
Digit span weighted score	6.4	6.5	7.6	7.8
Arithmetic weighted score	6.1	8.5	8.1	6.6
Similarities weighted score	6.5	9.0	8.5	9.0
Vocabulary weighted score	5.8	8.1	8.4	7.7
Picture arrangement weighted score	7.4	10.0	9.3	10.4
Picture comprehension weighted score	8.3	9.6	10.6	9.9
Block design weighted score	6.8	9.2	11.3	10.9
Object assembly weighted score	9.8	10.4	11.2	11.3
Digit symbol weighted score	6.6	9.3	9.4	8.8

TABLE 23

WECHSLER-BELLEVUE TEST VERBAL SCALE MINUS PERFORMANCE SCALE
(Test-Initial-Measure)
Number of cases in Groups 1N, 1, 2, and 3 falling
in each category listed below

Group	1N Study Negro	1 Study White	2 Hosp. White	3 Comb. White
Total No. Cases	25	26	20	51
No data	0	0	0	0
36 or more	0	0	0	0
26 to 35	0	2	1	0
16 to 25	2	1	0	3
6 to 15	7	6	1	8
5 to -5	8	5	6	15
-6 to -15	5	6	7	14
-16 to -25	3	3	5	8
-26 to -35	0	3	0	2
-36 or more negative	0	0	0	1

TABLE 24

STRONGEST DRIVE OF SUBJECT*, SENTENCE COMPLETION TEST
(Test-Initial-Measure)
Number of cases in Groups 1N, 1, 2, and 3 falling
in each category listed below

Group	1N Study Negro	1 Study White	2 Hosp. White	3 Comb. White
Total No. Cases	25	26	20	51
Omitted	0	0	0	0
Unclear	9	10	6	16
Passive dependence	2	2	0	0
Love affiliation	3	5	3	10
Prestige	4	6	10	8
Health	0	0	0	0
Escape	5	3	1	13
Independence	0	1	0	2
Economic	0	0	0	1
Sex	3	1	2	2

*If the subject exhibited two drives, both of which were "strongest" and of equal strength both were tabulated. As a result the sum of the frequencies for the several drives is greater than the number of individuals.

TABLE 25

REACTION TO FATHER, SENTENCE COMPLETION TEST
(Test-Initial-Measure)
Number of cases in Groups 1N, 1, 2 and 3 falling
in each category listed below

Group	1N Study Negro	1 Study White	2 Hosp. White	3 Comb. White
Total No. Cases	25	26	20	51
Omitted	0	0	0	0
Unclear	9	6	3	14
Rejection	1	0	0	3
Acceptance	15	20	17	34
Anxiety	0	0	0	0

TABLE 26

REACTION TO MOTHER, SENTENCE COMPLETION TEST
(Test-Initial-Measure)
Number of cases in Groups 1N, 1, 2 and 3 falling
in each category listed below

Group	1N Study Negro	1 Study White	2 Hosp. White	3 Comb. White
Total No. Cases	25	26	20	51
Omitted	0	0	1	0
Unclear	8	4	5	5
Rejection	0	0	0	1
Acceptance	17	22	14	45
Anxiety	0	0	0	0

TABLE 27

REACTION TO PEOPLE, SENTENCE COMPLETION TEST
(Test-Initial-Measure)
Number of cases in Groups 1N, 1, 2 and 3 falling
in each category listed below

Group	1N Study Negro	1 Study White	2 Hosp. White	3 Comb. White
Total No. Cases	25	26	20	51
Omitted	0	0	1	0
Unclear	14	11	9	27
Rejection	3	1	0	5
Acceptance	8	13	10	19
Anxiety	0	1	0	0

TABLE 28

REACTION TO AUTHORITY, SENTENCE COMPLETION TEST
(Test-Initial-Measure)
Number of cases in Groups 1N, 1, 2 and 3 falling
in each category listed below

Group	1N Study Negro	1 Study White	2 Hosp. White	3 Comb. White
Total No. Cases	25	26	20	51
Omitted	0	0	0	0
Unclear	10	12	7	17
Rejection	9	7	5	19
Acceptance	6	7	8	15
Anxiety	0	0	0	0

TABLE 29

DOMINANT REACTION TO FATHER, MOTHER, PEOPLE AND AUTHORITY
SENTENCE COMPLETION TEST (Test-Initial-Measure)
Number of cases in Groups 1N, 1, 2 and 3 falling
in each category listed below

Group	1N Study Negro	1 Study White	2 Hosp. White	3 Comb. White
Total No. Cases	25	26	20	51
Omitted	0	0	0	0
Unclear	10	9	7	13
Rejection	1	0	0	3
Acceptance	14	17	13	35
Anxiety	0	0	0	0

TABLE 30

FACTOR OR SITUATION WHICH CAUSES THE SUBJECT TO BE DEPRESSED
SENTENCE COMPLETION TEST (Test-Initial-Measure)
Number of cases in Groups 1N, 1, 2 and 3 falling
in each category listed below

Group	1N Study Negro	1 Study White	2 Hosp. White	3 Comb. White
Total No. Cases	25	26	20	56
Omitted	0	0	1	0
Unclear	22	23	13	36
Failure	0	1	2	5
Loss of love	3	2	4	10
Social disapproval	0	0	0	0
Health	0	0	0	0
Loss of independence	0	0	0	0
Guilt feelings	0	0	0	0

TABLE 31

FACTOR OR SITUATION WHICH CAUSES THE SUBJECT TO EXPERIENCE ANXIETY
SENTENCE COMPLETION TEST (Test-Initial-Measure)
Number of cases in Groups 1N, 1, 2 and 3 falling
in each category listed below

Group	1N Study Negro	1 Study White	2 Hosp. White	3 Comb. White
Total No. Cases	25	26	20	51
Omitted	0	0	0	0
Unclear	23	26	18	44
Failure	0	0	1	2
Social disapproval	0	0	0	0
Health	0	0	0	2
Loss of independence	0	0	0	0
Loss of love	2	0	1	2
Physical objects	0	0	0	1

TABLE 32

CATEGORY OF INDIVIDUAL HATED OR DISPLEASED BY THE SUBJECT WHEN
GUILT FEELINGS ARE AROUSED IN THE SUBJECT, SENTENCE COMPLETION TEST
(Test-Initial-Measure)
Number of cases in Groups 1N, 1, 2 and 3 falling
in each category listed below

Group	1N Study Negro	1 Study White	2 Hosp. White	3 Comb. White
Total No. Cases	25	26	20	51
Omitted	0	0	0	0
No single type of individual	10	15	10	26
Authority figures	0	0	0	1
Others	5	2	5	6
The subject himself	10	9	5	18

TABLE 33

REACTION OF THE SUBJECT IN RESPONSE TO ACTS OF AGGRESSION MADE AGAINST HIM SENTENCE COMPLETION TEST (Test-Initial-Measure)
Number of cases in Groups 1N, 1, 2 and 3 falling in each category listed below

Group	1N Study Negro	1 Study White	2 Hosp. White	3 Comb. White
Total No. Cases	25	26	20	51
Omitted	0	0	0	0
Unclear	11	15	5	26
Acceptance	2	3	6	10
Counterattack	0	2	2	0
Escape	2	1	0	1
Passive emotional reaction	10	5	7	14

TABLE 34

REACTION OF SUBJECT WHEN HE FAILS, SENTENCE COMPLETION TEST (Test-Initial-Measure)
Number of cases in Groups 1N, 1, 2 and 3 falling in each category listed below

Group	1N Study Negro	1 Study White	2 Hosp. White	3 Comb. White
Total No. Cases	25	26	20	51
Omitted	0	0	0	0
Unclear	15	11	9	23
Acceptance, without restriving [illegible]	10	10	7	18
Aggression or hostility, without [illegible]	0	0	0	0
[illegible]	0	4	2	9
[illegible]	0	1	2	1

TABLE 35

MMPI SCALE ON WHICH THE SUBJECT MADE HIS HIGHEST T-SCORE*
MINNESOTA MULTIPHASIC PERSONALITY INVENTORY (Test-Initial-Measure)
Number of cases in Groups 1N, 1, 2 and 3 falling
in each category listed below

Group	1N Study Negro	1 Study White	2 Hosp. White	3 Comb. White
Total No. Cases	25	26	20	51
Test invalid	10	1	2	1
Hypochondriasis (Hs)	5	5	3	7
Depression (D)	1	3	3	7
Hysteria (Hy)	1	1	1	0
Psychopathic deviate (Pd)	0	3	2	8
Interest (Mf)	0	1	0	4
Paranoia (Pa)	0	1	0	3
Psychasthenia (Pt)	3	3	2	3
Schizophrenia (Sc)	4	2	4	5
Hypomania (Ma)	2	7	3	16

*If the subject made an equally high score on the two scales in which he was highest, both are listed as highest; hence the number of "highest scales" listed is greater than the number of individuals. T-score values were obtained by reference to the MMPI manual.

TABLE 36

MEAN T-SCORES* MMPI CLINICAL SCALES AND DERIVED SCALES
MINNESOTA MULTIPHASIC PERSONALITY INVENTORY (Test-Initial-Measure)
Number of cases in Groups 1N, 1, 2 and 3 falling
in each category listed below

Group	1N Study Negro	1 Study White	2 Hosp. White	3 Comb. White
Total No. Cases	15	25	18	50
Hypochondriasis scale	67.3	60.6	56.0	54.0
Depression scale	62.1	55.0	57.8	53.9
Hysteria scale	60.5	55.7	57.8	53.5
Psychopathic deviate scale	60.5	53.6	58.3	55.9
Masculinity-Femininity scale	59.6	52.2	49.1	52.8
Paranoia scale	56.6	49.3	49.4	50.8
Psychasthenia scale	66.0	57.8	59.2	56.1
Schizophrenia scale	69.1	58.4	61.8	57.6
Hypomania scale	64.2	53.8	58.6	59.6
Welsh Anxiety Index	63.7	54.3	58.3	56.3
Welsh Internalization Ratio	105.3	101.4	99.7	97.9

*T-scores obtained by reference to the MMPI manual, except scores on Welsh Anxiety Index and Welsh Internalization Ratio which are raw scores.

TABLE 37

CODE TYPE, MINNESOTA MULTIPHASIC PERSONALITY INVENTORY
(Test-Initial-Measure)

Group	1N Study Negro	1 Study White	2 Hosp. White	3 Comb. White
Total No. Cases	15	25	18	50
None of the following	2	5	1	16
Type 12 or 21	1	3	0	1
Type 23 or 32	0	0	1	1
Type 27 or 72	1	1	1	3
Type 28 or 82	0	1	1	1
Type 31 or 13	1	2	3	0
Type 46 or 64	0	1	0	0
Type 68 or 86	0	0	0	2
Type 78 or 87	3	0	1	2
Type 49 or 94	1	4	1	8
Type 18 or 81	3	1	0	1
Type 43 or 34	1	0	2	1
Type 91 or 19	1	2	0	3
Type 39 or 93	0	1	1	0
Type 79 or 97	0	1	0	3
Type 89 or 98	1	2	4	3
Type 14 or 41	0	1	0	3
Type 24 or 42	0	0	1	2
Type 34 or 43	0	0	1	0

TABLE 38

SUBJECT'S HIGHEST MMPI T-SCORE ABOVE 70* (abnormal)
MINNESOTA MULTIPHASIC PERSONALITY INVENTORY (Test-Initial-Measure)

Group	1N Study Negro	1 Study White	2 Hosp. White	3 Comb. White
Total No. Cases	25	26	20	51
Test invalid	10	1	2	1
Hypochondriasis (Hs)	5	4	1	6
Depression (D)	1	1	1	2
Hysteria (Hy)	1	1	0	0
Psychopathic deviate (Pd)	0	0	2	5
Interest (Mf)	0	1	0	1
Paranoia (Pa)	0	1	0	3
Psychasthenia (Pt)	2	0	0	2
Schizophrenia (Sc)	3	1	2	5
Hypomania (Ma)	2	2	3	9

*If the subject made an equally high score on the two scales in which he was highest, both are listed; no scores below 70 listed.

TABLE 39

MEAN RORSCHACH SCORES, PRIMARY AND DERIVED
(RAW SCORES UNLESS OTHERWISE INDICATED*)
RORSCHACH TEST (Test-Initial-Measure)
Number of cases in Groups 1N, 1, 2 and 3 falling
in each category listed below

Group	1N Study Negro	1 Study White	2 Hosp. White	3 Comb. White
Total No. Cases	25	26	20	51
W	6.8	6.0	5.8	4.9
D	11.8	12.0	12.5	15.8
d	.3	1.3	.5	0
Dd	3.2	2.9	2.8	2.1
S	1.8	1.5	1.2	1.1
M	1.5	2.3	1.6	1.3
FM	1.5	2.2	2.1	3.0
m, mF, Fm	.4	.3	.2	.2
K, KF	.2	.2	.1	.1
FK	1.9	.5	.5	.5
F	12.1	13.6	13.8	14.3
Fc	1.2	1.5	.3	.2
c, cF	.1	.1	.5	1.2
C', C'F, FC'	1.2	.5	.4	.6
FC	1.5	1.5	.7	.9
CF	.9	.7	1.2	1.2
C	.2	0	.1	0
P	3.9	3.9	4.3	4.7
H	2.0	2.0	1.9	1.9
Hd	1.6	2.1	1.5	1.7
A	[illegible]	6.9	[illegible]	8.8
Ad	1.6	2.4	2.9	3.2
At	1.2	1.0	5.5	1.7
Ft	7.9	10.4	11.7	10.7
k, kF, Fk	.3	0	.2	.5
R (No. of responses)	19.0	23.5	21.9	23.1
Factor I'A Negativism (S, m, FC) T-score	56.8	55.0	49.5	49.5
Factor II' Freedom from Inhibitory Control (K, C, c, F) T-score	43.9	48.7	52.0	50.4
Factor III'B Impulsiveness (W, K, C, CF, c) T-score	54.2	52.0	53.3	49.7
Factor IV'C Compulsiveness (D, d, Dd, S, F) T-score	46.2	49.9	48.9	50.2
Factor D Integrative Ability (D, M, FM, FK, C', FC) T-score	43.4	48.0	46.8	50.9
Sum-C score	21.2	14.2	17.3	16.6
No. of aggressive responses	1.8	.9	.9	.8

*T-score scale based on the distribution of scores in the combat control group (Group 3)

TABLE 40

MEAN ACHROMATIC MINUS MEAN CHROMATIC REACTION TIME ON THE RORSCHACH TEST
(Test-Initial-Measure)
Number of cases in Group 1N, 1, 2 and 3 falling
in each category listed below

Group	1N Study Negro	1 Study White	2 Hosp. White	3 Comb. White
Total No. Cases	25	26	20	51
30 or more seconds	3	1	0	6
20 to 29 seconds	0	0	1	2
10 to 19 seconds	3	1	1	6
1 to 9 seconds	7	6	3	11
Zero	2	2	0	0
-1 to -9 seconds	7	8	8	9
-10 to -19 seconds	0	5	4	5
-20 to -29 seconds	2	2	2	3
-30 or more (negative) seconds	1	1	1	9

TABLE 41

DEPENDENCY, THEMATIC APPERCEPTION TEST
(Test-Initial-Measure)
Number of cases in Groups 1N, 1, 2 and 3 falling
in each category listed below

Group	1N Study Negro	1 Study White	2 Hosp. White	3 Comb. White
Total No. Cases	25	26	20	51
No indication of dependency	2	1	0	0
Markedly dependent	6	4	4	7
Average dependency	17	21	15	44
Markedly independent	0	0	1	0

TABLE 42

IMPULSIVITY, THEMATIC APPERCEPTION TEST
(Test-Initial-Measure)
Number of cases in Groups 1N, 1, 2 and 3 falling
in each category listed below

Group	1N Study Negro	1 Study White	2 Hosp. White	3 Comb. White
Total No. Cases	25	26	20	51
No indication of impulsivity	2	0	0	0
Markedly nonimpulsive	0	0	0	1
Average impulsivity	17	18	16	43
Markedly impulsive	6	8	4	7

TABLE 43

HOSTILITY, THEMATIC APPERCEPTION TEST
(Test-Initial-Measure)
Number of cases in Groups 1N, 1, 2 and 3 falling
in each category listed below

Group	1N Study Negro	1 Study White	2 Hosp. White	3 Comb. White
Total No. Cases	25	26	20	51
No indication of hostility	1	1	0	0
Normal range of hostility	15	8	9	21
Strong hostility towards others, not towards self	7	15	9	25
Strong hostility towards self, not towards others	0	0	0	2
Strong hostility towards self and others	2	2	2	3

TABLE 44

EDUCATION - YEARS OF SCHOOLING COMPLETED
(Interview-Initial-Measure)
Number of cases in Groups 1N, 1, 2 and 3 falling
in each category listed below

Group	1N Study Negro	1 Study White	2 Hosp. White	3 Comb. White
Total No. Cases	25	26	20	51
0-4 years	0	0	0	0
5-6 years	1	2	1	3
7-8 years	6	5	3	11
9-10 years	10	8	6	11
11-12 years	7	10	9	19
1-2 years college	1	1	1	7
3-4 years college	0	0	0	0
1 or more years graduate work	0	0	0	0

ARMY MEDICAL RESEARCH LABORATORY

FORT KNOX, KENTUCKY

REPORT NO. 113
1 April 1953

COLD INJURY - KOREA 1951-52*

Section IX
A BACTERIOLOGICAL, MYCOLOGICAL AND PATHOLOGICAL EVALUATION OF FROSTBITE

*Subtask under Environmental Physiology, AMRL Project No. 6-64-12-028, Subtask (III), Cold Injury Studies.

MEDICAL RESEARCH AND DEVELOPMENT BOARD
OFFICE OF THE SURGEON GENERAL
DEPARTMENT OF THE ARMY

SECTION IX

A BACTERIOLOGICAL, MYCOLOGICAL AND PATHOLOGICAL EVALUATION OF FROSTBITE INJURIES

by

Donald Frazier
Capt. MC, AUS

TABLE OF CONTENTS

A BACTERIOLOGICAL, MYCOLOGICAL AND PATHOLOGICAL EVALUATION OF FROSTBITE INJURIES

I. INTRODUCTION

A study of the bacteriology and pathology of frostbite was conducted at the Osaka Army Hospital, Osaka, Japan, during the winter 1915-52. In spite of the fact that clinical management of frostbite patients included intensive antibiotic therapy and local antisepsis it was of interest to determine the bacteriological status of their wounds. The bacteriological and mycological study consisted of 296 cultures of material from lesions of 104 soldiers hospitalized with frostbite wounds. The source of 191 bacterial and 105 fungal cultures is presented in Tables 1 and 2.

TABLE 1

DISTRIBUTION OF 191 BACTERIAL CULTURES FROM 130 LESIONS IN 88 CASES OF FROSTBITE ACCORDING TO DEGREE AND SITE OF INJURY

Degree of Frostbite	Number of Patients	Number of Lesions	Number of Cultures Completed		
			Hands	Feet	Total
First	—	—	—	—	—
Second	29	42	24	26	50
Third	35	50	16	56	72
Fourth	24	38	11	58	69
Total	88	130	51	140	191

II. RESULTS

A. Bacteriology and Mycology

Of the 191 cultures for bacteria, 97 were negative and

TABLE 2

DISTRIBUTION OF 106 FUNGAL CULTURES FROM 104 LESIONS IN 102 CASES OF FROSTBITE ACCORDING TO DEGREE AND SITE OF INJURY

Degree of Frostbite	Number of Patients	Number of Lesions	Number of Cultures Completed			
			Hands	Feet	Ear	Total
First	2	2	—	2	—	2
Second	38	39	15	25	1	41
Third	37	37	6	31	—	37
Fourth	25	26	3	23	—	26
Total	102	104	24	81	1	106

94 were positive. The distribution of the findings in accordance with degree and site of injury is shown in Table 3. Twelve types of bacteria were isolated from hand and foot lesions of patients with several degrees of frostbite. Non-hemolytic staphylococci were the most common organism in the lesions, appearing in 52 out of 140 cultures or 37.1% (Table 4). Inspection of the culture data revealed that no single type of organism predominated for any degree or site of injury. The proportion of positive cultures among the various degrees of cold injury indicated that the incidence of infection of fourth degree lesions was highest, that of third degree lesions next, and second degree injuries possessed the lowest incidence. The organisms cultured from the vesicles and open lesions caused

TABLE 3

DISTRIBUTION OF POSITIVE AND NEGATIVE CULTURES FOR BACTERIA IN 191 LESIONS IN ACCORDANCE WITH DEGREE OF FROSTBITE

Degree of Frostbite	Number of Cultures	Bacterial Cultures in Accordance with Site of Lesion						
		Hands		Feet		Total		
		Negative	Positive	Negative	Positive	Negative	Positive	% Pos.
First	—	—	—	—	—	—	—	—
Second	50	16	8	19	7	35	15	30.0
Third	72	[illegible]	7	28	28	37	35	48.6
Fourth	69	4	7	21	37	25	44	63.8
Total	191	29	22	68	72	97	94	49.2

TABLE 4

TYPES OF BACTERIA ISOLATED IN CULTURES OF MATERIAL FROM LESIONS OF FROSTBITE PATIENTS

Bacteria	Number of Cultures		
	Feet	Hands	Total
Staphylococci, non-hemolytic	45	7	52
Staphylococci, hemolytic, coagulase negative	29	9	39*
Bacillus subtilis	9	7	16
Staphylococci, hemolytic, coagulase positive	12	3	15
Paracolon bacilli	6	2	8
Streptococci, beta-hemolytic	2	1	3
Corynebacterium xerosis	2	-	2
Alcaligenes faecalis	-	1	1
Proteus morgani	-	1	1
Escherichia freundii	1	-	1
Escherichia intermedium	1	-	1
Streptococcus, non-hemolytic	1	-	1
Total	108	31	140*

* Includes one culture with site not recorded.

by cold injury were not those generally considered pathogenic in the majority of instances. Because of their common occurrence their presence could be expected as secondary invaders of open cutaneous lesions. The high incidence in the more severe degrees of cold injury can be readily explained by the longer course of the lesions with longer exposure to, and greater chance of, invasion by secondary contaminants.

Serial cultures were made of 42 lesions, the time between cultures varying from 1 to 19 days. Eighteen of these series remained positive over a period of time averaging 4 days. Infection of sterile vesicles following aspiration occurred in 26 series. These findings indicated that aspiration of non-infected vesicles was followed by secondary infection in a large number of cases and the application of routine antiseptic and antibiotic measures could not prevent such contamination in many instances. This further supports the doctrine that all vesicles and bullae should be kept intact and not debrided in order to prevent infection and subsequent delay in healing of lesions.

Of the 106 cultures for fungi made from frostbite lesions, 96 were negative and nine were positive for pathogenic fungi. Seven cultures of Trichophyton mentagrophyte, one of Trichophyton rubrum and one of Trichophyton sulfureum were obtained. All positive cultures were from the feet.

It was concluded from the findings that bacterial and fungal infections were of little significance in these frostbite lesions. Wet gangrene of the lesions was a rarity among the frostbite patients. It should be emphasized however, that these patients were receiving intensive daily antibiotic therapy and daily local treatment of injured parts.

B. Pathology

The study of the pathology of frostbite injuries was made on 13 specimens from 11 patients. These tissue specimens had been damaged by cold and consisted of two major types of diseased tissues, namely, gangrenous parts and chronic ulcerations.

In the cases of chronic ulceration, the ulcer beds were made up of dense chronic inflammatory tissue in various, generally advanced, states of organization and cicatrization. In the cases of gangrene, the gangrenous tissue was separated from viable tissue by a bed of granulation tissue also in various, generally advanced, states of organization and cicatrization. In one case of gangrene, the line of demarcation was primarily one of intense acute necrotizing inflammation with only scant organization such as would be found at the demarcation zone of a case of relatively early gangrene (15 days post-frostbite).

The soft tissues that appeared grossly normal and which were removed in conjunction with the ulcerations and gangrene

showed essentially the same changes in all specimens. The changes were those of chronic inflammation of varying intensity. Any variations were those of quantity rather than quality. The inflammation was most intense in the loose supporting connective tissue around blood vessels of all sizes, nerves and dermal appendages.

The fat tissues were mildly or chronically inflamed and a few scattered foci of necrosis were present. Many of the involved fat cells were depleted of their fat.

The skeletal muscle, away from the lines of demarcation of gangrenous specimens was not abnormal except for the mild chronic inflammation generally present in all the soft tissues. The only muscle necrosis seen was in relation to areas of demarcation.

The dermal appendages away from the ulceration and demarcation lines were not abnormal except for the surrounding chronic inflammation. Degenerative changes, however, were present in the sweat glands in areas closely adjacent to ulcerations and demarcations.

The nerves had only a very few chronic inflammatory cells within their trunks, although the surrounding loose connective tissue was intensely inflamed. Degenerative changes of the nerves were not noted except within ulcer beds and demarcation inflammatory tissue.

The blood vessels of all calibers were generally devoid of recent thrombi as well as evidence of old thrombi except

in areas of tissue necrosis, reorganizing ulcer beds and demarcated granulation tissue. Severe thrombophlebitis was present in the grossly normal tissue far removed from gangrenous tissue. The involved veins could readily be traced to the separation line of the gangrenous parts and the remote phlebitis was attributed to extension from this area. Capillary thrombi were not present in any areas of the specimens. The adventitial layer of the larger vessels and the loose connective tissues around the larger and smaller vessels had a chronic inflammatory reaction, the intensity of which varied with the chronic inflammation of the area in general.

Hemorrhages in essentially normal areas were few and largely fresh. In the areas of gangrenous demarcation moderate amounts of blood, degenerated and fresh, were present in variable sized hemorrhages.

The bone at a considerable distance from the demarcations and ulcerations was not generally abnormal. However, one specimen showed a slight osteogenic process without an associated marrow abnormality. In a few specimens some chronic inflammatory changes and fibrosis of the marrow were present, but these changes were not associated with alterations of the spicules. In the areas of ulceration and demarcation, the changes most frequently seen were marked active osteogenesis associated with some osteolysis and marked chronic inflammation of the marrow coupled with extensive fibrous replacement. In one specimen, however,

with an exposed bone surface, the bone and its marrow were not abnormal. In another specimen the exposed bone was the seat of an active acute inflammation of the marrow. The bone of a cicatrized toe tip had evidence of marked bony re-absorption but without any appreciable marrow alterations.

The gangrenous tissues from all specimens were uniformly alike being involved in a non-specific necrosis.

The changes present in 13 specimens were non-specific and were those generally seen in association with any chronic ulcerative process and in association with demarcation of any gangrenous process other than classical gas gangrene caused by Clostridia. Nothing was present that could be specifically attributed to frostbite. Because the lapse of time between the incidence of frostbite and the examination of tissue was so long (27 to 134 days) any tissue changes which might otherwise have characterized frostbite were probably obscured by non-specific changes. The study of tissue removed so long after the occurrence of frostbite contributed little toward the understanding of the pathogenesis of this type of cold injury.

III. CONCLUSIONS

Of 191 cultures of material from frostbite lesions 49% were positive for bacteria. Twelve types of bacteria, commonly found in the gastrointestinal tract, on skin and in soil, were identified. No given bacteria were characteristic of frostbite lesions nor could any

be related to severity of cold injury. The bacteria were considered essentially non-pathogenic and, to a large extent, secondary invaders in open lesions.

Of 105 cultures of material from the frostbite lesions examined, 96 were negative and nine were positive for pathogenic fungi. The fungi consisted of three types of Trichophyton, namely, T. mentagrophyte, T. rubrum and T. sulfureum, all of which are commonly found in cases of epidermophytosis of the feet.

The pathology of frostbite lesions in tissues studied was essentially that of chronically inflamed, ulcerated and gangrenous tissue. Changes in muscle and bone, as well as dermal appendages, nerves and blood vessels were described.

Extensive antibiotic therapy and lack of early tissue specimens (27 to 134 days post-frostbite) may well have obscured any bacteriological or pathological changes which might be characteristic of frostbite.

ARMY MEDICAL RESEARCH LABORATORY

FORT KNOX, KENTUCKY

REPORT NO. 113
1 April 1953

COLD INJURY - KOREA 1951-52*

Section X
FOOT-SWEAT STUDIES ON FROSTBITE CASUALTIES, KOREA, 1951-52

*Subtask under Environmental Physiology, AMRL Project No. 6-64-12-028, Subtask (SK), Cold Injury Studies.

MEDICAL RESEARCH AND DEVELOPMENT BOARD
OFFICE OF THE SURGEON GENERAL
DEPARTMENT OF THE ARMY

SECTION X

FOOT-SWEAT STUDIES ON FROSTBITE CASUALTIES

KOREA, 1951-52.

by

Lt. Col. Kenneth D. Orr, MC, USA

and

Lt. Domenic A. Vavala, MSC, USAF

TABLE OF CONTENTS

FOOT SWEAT STUDIES ON FROSTBITE CASUALTIES
KOREA, 1951-52

I. INTRODUCTION

Exposure to cold resulting in a frostbite injury may alter the mechanism of sweating in the involved area. An early manifestation of cold injury is anhidrosis which is a transient condition in first, second and third degree frostbite. Ungley (1) in studies on immersion foot demonstrated both anhidrosis and sensory loss in the injured area. A similar finding was reported by Davis, Scarff, et al. (2) in high-altitude frostbite patients. Degenerative changes in the sweat glands of frostbite patients have been described by Wadsworth and Whitney (3). In a comparison of early and late frostbite lesions, Friedman and Kritzler (4) showed changes ranging from degenerative processes in the epithelial linings of sweat glands to atrophied sweat ducts and degeneration of surrounding connective tissue.

Anhidrosis in first, second and third degree frostbite of the feet is usually followed by hyperhidrosis but the exact time of onset and causes of this phenomenon are not known. The duration of hyperhidrosis and the total amount of sweat produced for each degree of frostbite has never been reported. Excessive sweating of feet previously injured by frostbite is a frequent complaint. Excessive sweating of the feet with the necessity for increased attention to foot hygiene may decrease the operational efficiency of the infantry soldier. Hyperhidrosis of the feet during winter months could contribute materially to loss of body heat.

Consequently, an investigation of sweating of the feet was conducted in order to establish the following:

1) The presence and duration of the anhidrotic state in frostbitten extremities.
2) The time of onset of sweating in the injured extremities.
3) Qualitative and quantitative measures of foot sweat after frostbite for each degree of injury.
4) The presence or absence of hyperhidrosis of feet injured by frostbite.
5) The presence of a racial difference in foot sweat output as a possible explanation for the differences in injury incidence rates between Negroes and Whites.

II. METHODS

Foot-sweat measurements were performed at the Cold Injury Center of Osaka Army Hospital, Osaka, Japan, from November 1951 to March 1952. The study group included 93 patients who had incurred frostbite of the feet in Korea during the winter of 1951-52. The presence and amount of sweating was determined by using the Minor Starch-Iodine Test (5), quantitative gravimetric measurements of total foot sweat, and measurements of the electrical resistance of the skin of the feet.

A. Minor Starch-Iodine Test

The Minor Starch-Iodine test was used to determine the presence or absence of anhidrosis in patients after injury by frostbite.

Minor's Solution consists of:

Iodine, C. P. . . . . 1.52 gms.

Castor Oil . . . . 10 cc.

Alcohol, absolute, q. s. . . . . . . 100 cc.

Finely divided rice-powder is used as the starch source. The tests were conducted in a room where the temperature was maintained between 84° and 86° F. with a relative humidity of approximately 48%. The patients were at strict bed rest, were clothed in a pair of cotton pajamas and covered by one sheet and blanket which extended from the neck to just below the knees. The patients feet were cleansed with alcohol. This was followed by a 30 minute equilibration period. At the end of the equilibration period the feet were painted with a heavy coat of Minor's Solution which was allowed to dry. The rice powder was then dusted over the area covered by Minor's Solution and the color test read 30 minutes later.

The appearance of any degree of blue color on the foot was interpreted as a positive test, i. e., sweat was present. The absence of a visible color change was recorded as a negative test. To confirm a negative test the dusted area was rubbed with a piece of cotton. If no blue discoloration appeared on the cotton, the negative result was substantiated.

B. Quantitative Measurements of Foot Sweat

Quantitative measurements of foot sweat were made on the following five groups of soldiers:

1) Cases with bilateral frostbite of the feet.
2) Patients with contralateral uninjured feet.

3) Cases with uninjured feet but with frostbite of the hands.

4) Osaka control subjects.

5) Fort Knox control subjects.

The frostbite patients had either a first, second or third degree lesion which was either bilateral or unilateral. There were 15 patients who had frostbite of the hands and no overt cold injury of the feet. Measurements were started 7 to 14 days after injury and repeated at approximately weekly intervals for a period of 5 months. The average number of determinations per patient was 10 with a range from four to 18. The measurements were conducted in the hospital wards where the ambient temperatures fluctuated between 72° and 76° F. Initiation of the test depended upon two factors: the presence of a positive starch-iodine test, and sufficiently healed frostbite lesions to avoid infection and trauma.

The Osaka controls were 24 medical patients who were hospitalized in the Osaka Army Hospital for conditions other than frostbite. These patients were combat infantrymen who had been evacuated from Korea at approximately the same time as the cases of frostbite. The subjects had no neurological disorders or injuries of the lower extremities and their feet were considered normal. Only one sweat determination per foot was made on each control from 2100 to 0800 hours employing the same standard conditions and following the same procedure as outlined below under nocturnal measurements.

The Fort Knox controls were 24 normal male laboratory technicians whose mean age was 25 years with a range from 18 to 30. A total of four measurements per foot were made in one month (October 1952) at Fort Knox, Kentucky. The procedures employed for the determinations are described below under nocturnal measurements. Each subject was equilibrated for 1.5 hours before the collection of sweat was initiated by remaining at bed rest with the bare feet exposed to an ambient temperature of 74° F. The subjects were not permitted to smoke.

The following items were used for each patient:

1) Two plastic vinylite bags.
2) One pair wool cushion sole socks.
3) One pair rubber barrier socks.
4) Two hand towels.

1. Nocturnal Measurements.

The wool socks and hand towels were desiccated to a constant weight in a drying oven. Into each plastic bag was placed one wool sock, one rubber barrier sock and one hand towel. The top of the bag was sealed with a rubber band and weighed to the nearest tenth of a gram.

The collection of foot sweat was started at 2100 hours and terminated at 0800 hours. This period of time for collection of sweat was selected since the patient would be at complete bed rest under approximately basal conditions. To minimize the uptake of

moisture from the air only one bag was opened at a time. Each foot was clothed in the wool sock and covered by the rubber barrier sock. The desiccated hand towels remained inside the bags. The patients were inspected by the investigator at 2100, 2300 and 2400 hours and by the nurse at 0100, 0300 and 0500 hours to insure that the patients remained in bed with their feet exposed to room temperature. In addition, the rubber barrier sock was examined to make certain it was in proper position and snugly fitted to prevent sweat loss by evaporation.

At 0800 hours the rubber barrier and wool socks were removed and any residual moisture on the foot was wiped off onto the respective desiccated hand towels. All items for each foot were then placed in their respective labeled bags. Each bag was then weighed, and the amount of sweat collected was recorded as grams of foot sweat per 11 hours.

2. Diurnal Measurements.

The daytime collections of sweat were made from 0800 to 1900 hours, following the same procedures (except for activity) as previously described for the nighttime collections. A total of 54 frostbite patients from the nocturnal group had from three to six daytime collections made over a period of 10 to [illegible] days post-injury. The activity of the daytime group was not rigidly supervised or controlled. The patient was allowed to move freely about the ward, take part in bedside games or remain in

bed during the collection period. He was not allowed to leave the ward between 0800 and 1900 hours and his meals were served at the bedside. Hourly checks by the nurse or investigator were made to assure that the socks were being worn properly.

C. Skin Resistance Measurements

The principle of skin resistance measurement as defined by Richter involves differences in skin resistance levels rather than actual quantitative measurements of this resistance. Richter further states that the resistance varies inversely with sweat gland activity. The modal number of measurements of skin resistance performed per patient was four with a range from two to eight.

A modification of Richter's dermometer (6, 7, 8) was used. A diagram of the electrical circuit of the modified dermometer is presented in Figure 1. The scale on the meter of the dermometer was graduated in tenths of a mho* from 0 to 5 mhos. A scale reading of zero indicated high skin resistance or the absence of sweat gland activity. A scale value of 5 mhos was the maximal activity the instrument was capable of recording although it failed to reflect the maximal actual secretions. An appropriate linear relationship between sweat gland activity and scale reading prevailed in the intermediate zone.

---

*The mho is a practical unit of conductance (the reciprocal resistance). It is the conductance of a body through which one ampere of current flows when the potential difference is one volt.

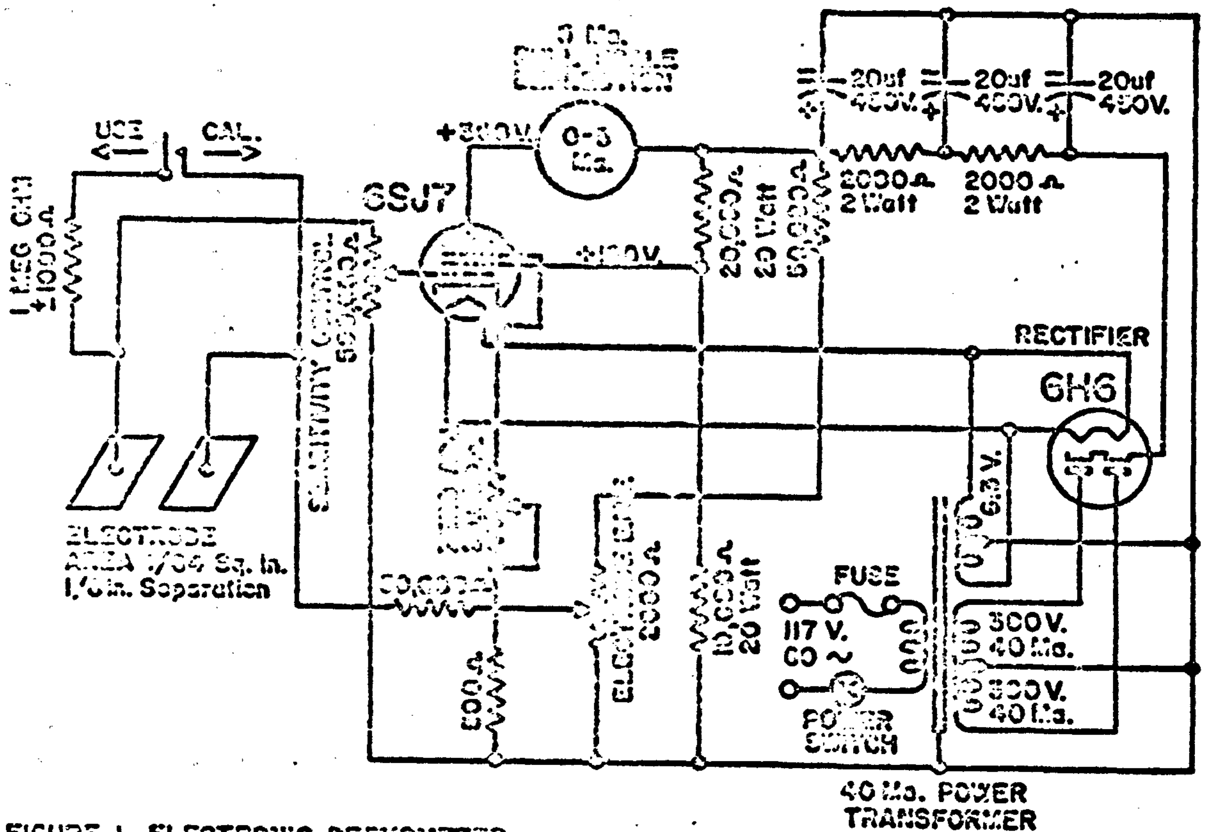
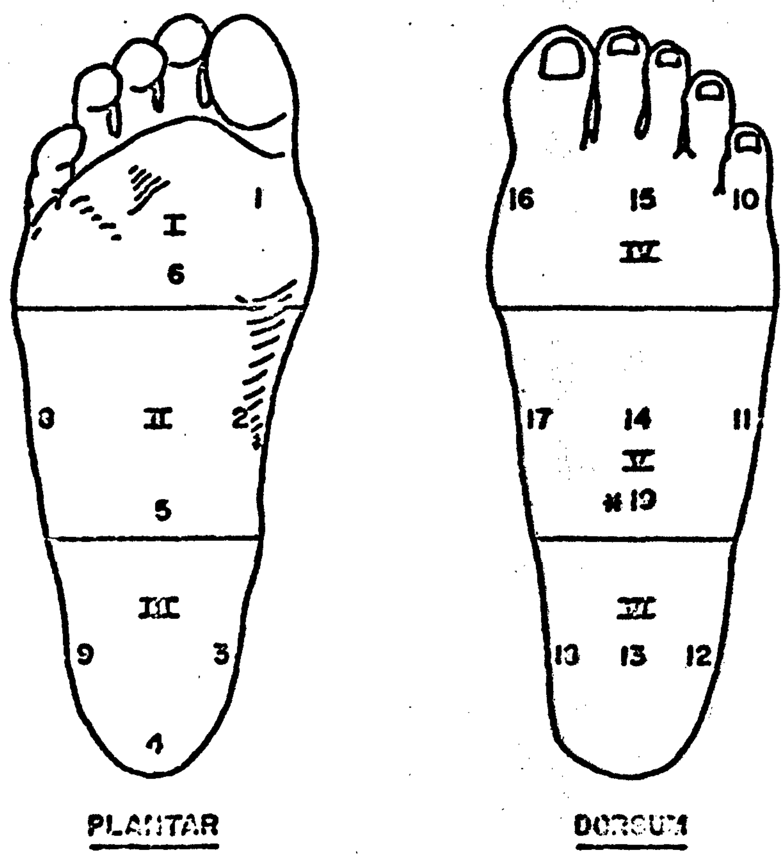


FIGURE I. ELECTRONIC DERMOMETER.
Modification of dermometer by Cpl. Robert A. Crawford, A.M.R.L.



LOCATED AT LEVEL OF PROXIMAL TARSAL BORDER.

FIGURE 2. STANDARD POINTS AND AREAS USED IN SKIN RESISTANCE MEASUREMENTS.

Measurements were conducted in an ambient temperature of 70° to 74° F. The feet were not subjected to any special preparation prior to this procedure. Patients were at bed rest with feet exposed to the air for at least 2 hours prior to measurement. Nineteen standard points per foot were selected for each measurement. Nine points were on the plantar surface and 10 on the dorsal surface of the foot (Figure 2). The plantar and dorsal surfaces of the foot were further divided into proximal, middle and distal thirds. This division of the foot permitted the electrical resistance of the skin of the six general areas to be compared. The electrode was placed by simple contact on each point; readings were taken directly from the meter and recorded as mhos.

III. RESULTS

A. Minor Starch-Iodine Test

A positive test was obtained on 73 out of 78 patients. These 73 patients were first tested 12 to 14 days post-injury. Three patients with second degree and two with third degree when first tested were found to be in an anhidrotic state. In these five patients a positive Minor test was first obtained 23 days after injury.

B. Foot-Sweat Measurements

Measurements of foot sweat were performed on a total of 62 frostbite patients. Mean sweat values for the several 11 hour collections were determined for each foot. In order to correlate the changes in sweat production with

time post-injury the measurements of foot sweat were divided into four 30 day periods (1-30, 31-60, 61-90, 91-120). This division tended to equalize the number of determinations for each patient and yet not mask differential sweat production between periods (see Table 1 for the distribution of feet used in this study).

TABLE 1

DISTRIBUTION OF FEET STUDIED FOR SWEAT OUTPUT.

Degree of Injury of Feet	Right	Left
None (Cuba controls)	24	24
None (Knox controls)	24	24
None (Only hands injured)	15	15
None (Contralateral foot injured*)	5	3
First	7	8
Second	12	20
Third	24	15
Total	111	109

*These contralateral injured feet appear under either second or third degree injuries.

1. First Degree Frostbite

During the first 30 day period after injury the mean sweat values for the right foot of six patients ranged from 7.0 to 14.5 grams per 11 hours (Table 2). The left foot of seven patients during this first period had a mean sweat production ranging from 5.5 to 19.4 grams per 11 hours (Table 3). The mean of means for the right and left foot among the 13 patients showed a progressive increase in sweat production up to 90 days after injury. Comparisons between the right and left foot for each

post-injury period showed the mean values not to be significantly different from one another ("t" values ranged from 0.653 to 1.961).

TABLE 2

DISTRIBUTION OF SWEAT VALUES FOR FIRST DEGREE FROSTBITE OF THE RIGHT FOOT WITH RESPECT TO POST-INJURY COLLECTION PERIOD.

Subject No.	Days Post-Injury 1-30		31-60		61-90		91-120	
	Mean Ft Sweat gm/11 hr	S.D.	Mean Ft Sweat gm/11 hr	S.D	Mean Ft Sweat gm/11 hr	S.D	Mean Ft Sweat gm/11 hr	S.D
17	7.93	±0.673	14.22	±0.950	19.65	±1.150	19.53	±6.147
23	9.33	±1.433	19.68	±4.665	24.05	±4.110	25.02	±3.594
33	7.46	±2.442	10.30	±1.355			15.05	±2.900
39	7.03	±1.533	16.23	[illegible]	22.85	±1.450		
40	9.75	±0.050	23.63	[illegible]	21.60	±0.030		
43			10.65	±3.[illegible]	13.32	±2.319	15.00	±6.375
58	14.47	±1.565	16.30	±0.6[illegible]				
Mean of Means	9.33	±2.994	15.69	±5.105	20.40	±4.496	18.90	±6.005

2. Second Degree Frostbite

The mean foot-sweat values for the right foot of 12 patients ranged from 5.4 to 17.5 grams per 11 hours (Table 4). The left foot of 19 patients for the same period varied from 4.7 to 20.3 grams per 11 hours (Table 5). The mean of means for the right and left foot showed a progressive increase in the amount of sweat collected up to 90 days after injury. Comparisons between the mean of mean values for the right and left foot in each period showed them not to be significantly different ("t" values

ranged from 0.346 to 1.468).

TABLE 3

DISTRIBUTION OF SWEAT VALUES FOR FIRST DEGREE FROSTBITE OF THE LEFT FOOT ACCORDING TO POST-INJURY COLLECTION PERIOD.

Subject No.	Days Post-Injury 1-30 Mean Ft Sweat gms/11 hr	S.D	31-60 Mean Ft Sweat gms/11 hr	S.D	61-90 Mean Ft Sweat gms/11 hr	S.D	91-120 Mean Ft Sweat gms/11 hr	S.D
5	6.87	±4.121	10.45	±2.637	13.55	±2.500	11.93	±1.231
21	5.50	±1.325	12.24	±2.033				
41	7.95	±1.343	13.46	±1.156	22.45	±3.350		
48			10.25	±1.312	16.45	±5.005	13.40	±1.283
58	15.03	±1.747	15.76	±1.143				
65	19.40	±15.400	22.96	±9.436	16.15	±1.250		
82	10.95	±1.700	15.55	±4.671				
87	12.15	±1.300	13.53	±0.718				
Mean of Means	11.12	±5.303	14.23	±4.342	17.15	±4.348	12.67	±1.470

3. Third Degree Frostbite

The mean grams of sweat collected during the different post-injury periods for the right and left foot among 30 patients is shown in Tables 6 and 7. The mean of mean values for each foot showed a progressive increase in the amount of sweat collected up to 90 days after injury. Comparisons between the mean of mean values for the right and left foot yielded no significant differences ("t" values ranged from 0.027 to 1.255).

4. Comparison of Foot Sweat by Degree of Injury

The mean values for the right and left feet within each

TABLE 4

DISTRIBUTION OF SWEAT VALUES FOR SECOND DEGREE FROSTBITE OF THE RIGHT FOOT ACCORDING TO POST-INJURY COLLECTION PERIOD

Subject No.	Days Post-Injury							
	1-30		31-60		61-90		91-120	
	Mean Ft Sweat gms/11 hr	S.D.	Mean Ft Sweat gms/11 hr	S.D.	Mean Ft Sweat gms/11 hr	S.D.	Mean Ft Sweat gms/11 hr	S.D.
5	5.40	± 0.200	11.10	± 1.663	14.85	± 1.350	11.62	± 0.773
15	8.60	± 1.020	9.43	± 3.283				
34	16.24	± 4.318	13.85	± 2.650	23.85	± 2.750	14.35	± 3.750
37	7.23	± 1.644	11.85	± 4.374	15.23	± 1.835	21.50	± 4.597
44	5.50	± 0.374	10.30	± 1.474	16.05	± 1.050	17.10	± 1.257
52	10.77	± 2.199	14.62	± 4.275	14.00	± 3.793		
53	17.45	± 1.532	13.82	± 1.596	14.23	± 1.322		
57	13.63	± 1.721	12.85	± 0.650				
68	13.86	± 3.711	16.52	± 4.963	15.70	± 1.283		
70	17.40	± 2.571	18.02	± 4.750	12.00	± 3.800		
75	15.83	± 1.591	15.17	± 2.527	12.95	± 0.950		
79	9.86	± 1.370	12.65	± 0.642	14.85	± 1.950		
Mean of Means	11.81	± 4.707	13.35	± 2.627	15.45	± 3.367	16.14	± 4.867

degree of injury and post-injury period were combined. The mean values for sweat collected per 11 hours per foot for first, second and third degree frostbite respectively within each post-injury period were compared. Except for the comparison between second and third degree frostbite in the 31-60 day period, no other significant differences in foot sweat values by degree of injury were found (Table 8). The difference between the mean sweat values of second and third degree in the 31-60 day period was 2.8 grams. When this difference in mean foot-sweat value

TABLE 5

DISTRIBUTION OF SWEAT VALUES FOR
SECOND DEGREE FROSTBITE OF THE LEFT FOOT ACCORDING TO
POST-INJURY COLLECTION PERIOD

Subject No.	Days Post-Injury							
	1-30		31-60		61-90		91-120	
	Mean Ft Sweat gms/11 hr	S.D.	Mean Ft Sweat gms/11 hr	S.D.	Mean Ft Sweat gms/11 hr	S.D.	Mean Ft Sweat gms/11 hr	S.D.
2	4.66	± 0.386	10.78	± 2.462	11.00	± 0.800	8.67	± 3.006
8	12.05	± 2.550	19.90	± 5.492	23.13	± 6.839	13.73	± 3.842
15	6.53	± 1.039	11.48	± 2.105	23.00	± 4.400		
19	5.43	± 0.741	10.46	± 2.723	17.90	± 1.100	19.60	± 6.865
20	6.63	± 1.144	12.31	± 1.642	14.36	± 1.263	12.92	± 0.517
26			14.29	± 2.970	13.40	± 0.904	19.42	± 5.409
37	6.50	± 0.833	12.04	± 6.135	13.45	± 0.350	16.50	± 1.700
39	14.33	± 3.836	17.56	± 2.818	22.60	± 1.200		
40	10.80	± 0.356	21.67	± 6.770	19.60	± 1.200		
43	6.53	± 2.502	11.53	± 1.676	15.20	± 1.685	11.30	± 1.0[illegible]1
44	5.56	± 0.732	11.32	± 1.725	17.30	± 1.500	19.00	± 2.780
52	12.02	± 2.319	14.90	± 5.2[illegible]3	16.82	± 5.260		
53	16.55	± 2.921	17.66	± 3.755	15.40	± 2.699		
57	14.00	± 2.718	11.95	± 0.250				
67	15.50	± 5.505	15.96	± 7.653	14.23	± 2.894		
68	20.26	± 1.655	18.14	± 2.567	15.56	± 1.249		
79	13.33	± 1.835	12.77	± 0.980				
82	10.95	± 0.850	14.93	± 4.024	17.65	± 0.250		
84	11.90	± 1.806	19.00	± 6.100				
86	13.95	± 0.850	21.62	± 5.078				
Mean of Means	10.92	± 4.556	15.02	± 3.792	17.23	± 3.630	15.14	± 4.398

was compared to the differences between the other degrees of frostbite no significance was found (t=1.456, P >.10), thus strengthening the impression that the observed difference occurred by chance. It was concluded that the degree of injury does not materially influence the rate of sweating in the injured foot.

TABLE 6

DISTRIBUTION OF SWEAT VALUES FOR
THIRD DEGREE FROSTBITE OF THE RIGHT FOOT ACCORDING TO
POST-INJURY COLLECTION PERIOD

Subject No.	Days Post-Injury							
	1-30		31-60		61-90		91-120	
	Mean Ft Sweat gms/11 hr	S.D.	Mean Ft Sweat gms/11 hr	S.D.	Mean Ft Sweat gms/11 hr	S.D.	Mean Ft Sweat gms/11 hr	S.D.
2	6.20	±0.216	11.33	±3.043	11.80	±1.400	10.67	±1.594
3	12.05	±2.504	13.45	±3.764	20.30	±4.700		
8	14.90	±3.116	30.92	±9.[illegible]	30.40	±2.551	16.20	±5.145
9			10.42	±1.635	15.65	±1.[illegible]	13.63	±0.403
19	6.05	±1.132	12.72	±3.499	15.85	±1.850	13.70	±4.673
21	6.86	±1.091	10.53	±1.784				
25	20.54	±5.051	24.72	±3.[illegible]	20.95	±1.214	22.90	±3.000
27	5.63	±0.634	13.14	±3.[illegible]	10.96	±7.323	15.06	±2.715
32	20.25	±6.115	20.10	±4.951	20.15	±3.118		
33			14.18	±3.5[illegible]	19.03	±1.179	14.76	±2.207
35			12.95	±3.079			11.03	±0.613
38			10.60	±1.921	15.90	±2.500		
41	8.65	±1.927	16.03	±1.5[illegible]	17.20	±5.600		
49			13.85	±5.059	13.40	±3.645	15.23	±1.557
50	16.63	±4.[illegible]	23.00	±4.912	13.26	±2.093		
54	11.52	±4.105	14.56	±2.451	15.60	±2.800		
65	6.30	±2.100	29.40	±3.561	15.50	±1.700		
67	12.60	±1.435	13.43	±5.712	15.00	±2.412		
81	13.40	±0.[illegible]	26.03	±5.2[illegible]				
82	10.90	±4.[illegible]	19.05	±2.77[illegible]				
86	17.90	±1.700	19.85	±1.205				
87	11.90	±0.900	16.92	±4.926				
88	23.00	±4.300	26.90	±2.333				
92	22.20	±4.948	14.75	±0.723				
Mean of Means	13.31	±6.479	17.45	±6.355	17.49	±4.497	14.82	±3.751

5. Comparison of Foot Sweat by Time Post-Injury

Earlier analyses showed that there were no significant differences in the foot-sweat output for the right and left foot and for the different degrees of injury. The

TABLE 7

DISTRIBUTION OF SWEAT VALUES FOR THIRD DEGREE FROSTBITE OF THE LEFT FOOT ACCORDING TO POST-INJURY COLLECTION PERIOD

Subject No.	Days Post-Injury: 1-30 Mean Ft Sweat gms/11 hr	S.D.	31-60 Mean Ft Sweat gms/11 hr	S.D.	61-90 Mean Ft Sweat gms/11 hr	S.D.	91-120 Mean Ft Sweat gms/11 hr	S.D.
3	9.10	±1.143	17.61	±2.790	20.40	±6.000		
9			13.83	±6.500	13.86	±4.450	15.55	±5.946
17	10.73	±1.584	18.93	±7.327	19.90	±1.200	14.50	±3.203
23	11.60	±2.039	20.41	±5.933	24.63	±3.654	26.95	±3.703
25	17.43	±2.756	20.50	±2.[illegible]	20.22	±1.932	19.65	±2.950
27	5.36	±0.903	11.97	±2.[illegible]	17.03	±3.373	18.97	±5.947
33			14.17	±4.722	17.75	±0.792	14.[illegible]	±2.179
34			15.43	±5.367	22.35	±1.350	20.25	±5.[illegible]
36			13.51	±3.918			11.33	±0.[illegible]
38	5.20	±0.200	10.60	±2.402			15.90	±5.000
50	19.27	±3.667	[illegible]	±2.[illegible]	13.73	±2.114		
66	13.83	±3.570	15.[illegible]	±3.377	14.26	±1.597		
70	10.63	±2.654	17.34	±3.[illegible]	16.95	±1.450		
75	17.63	±1.936	13.97	±1.513	9.20	±3.000		
83	20.70	±2.000	[illegible].73	±3.[illegible]				
Mean of Means	13.97	±5.841	16.68	±4.294	17.54	±4.509	17.35	±4.747

mean foot-sweat values were therefore combined into a single value for each of the four 30 day post-injury periods. This grouping yielded a mean sweat output per foot per 11 hours for each post-frostbite period as follows: 1-30 days, 11.86 grams; 31-60, 15.70 grams; 61-90, 17.16 grams and 91-120 days, 15.77 grams. Comparisons between these values with respect to the post-injury periods are shown in Table 9. The foot-sweat value of the first period was significantly lower than the values for the second, third

TABLE 8

COMPARISON BETWEEN FOOT SWEAT VALUES FOR EACH POST-INJURY PERIOD ACCORDING TO DEGREE OF INJURY

Degree of Injury	Days Post-Injury	No. of Feet	Mean Ft Sweat gm/ 11 Hr.	S. D.	"t"	P
1st 2nd	1-30	13 31	10.29 11.27	± 4.167 ± 4.338	0.703	>.40
1st 3rd	1-30	13 30	10.29 13.41	± 4.167 ± 5.850	1.983	>.05
2nd 3rd	1-30	31 30	11.27 13.41	± 4.338 ± 5.850	1.619	>.10
1st 2nd	31-60	15 32	15.03 14.39	± 4.454 ± 3.307	0.496	>.60
1st 3rd	31-60	15 39	15.03 17.15	± 4.454 ± 5.399	1.474	>.10
2nd 3rd	31-60	32 39	14.39 17.15	± 3.307 ± 5.399	2.645	<.01
1st 2nd	61-90	9 26	19.95 16.54	± 4.226 ± 3.512	1.520	>.10
1st 3rd	61-90	9 28	19.95 17.51	± 4.226 ± 4.336	0.874	>.30
2nd 3rd	61-90	26 28	16.54 17.51	± 3.512 ± 4.335	0.906	>.30
1st 2nd	91-120	6 12	16.82 15.43	± 5.672 ± 4.159	0.514	>.60
1st 3rd	91-120	6 18	16.82 16.08	± 5.672 ± 4.243	0.293	>.70
2nd 3rd	91-120	12 18	15.49 16.08	± 4.159 ± 4.243	0.384	>.70

and fourth post-frostbite periods. The foot sweat collected in the 31-60 day period was significantly lower than that of the 61-90 day period. The remaining comparisons were not significant. These analyses indicated that there was an increase in foot sweat from time of injury up to the 61-90 day period after which the amount of foot sweat collected remained fairly constant.

TABLE 9

COMPARISON OF SWEAT VALUES FOR PATIENTS WITH FROSTBITTEN FEET ACCORDING TO TIME POST-INJURY

Days Post-Injury	No. of Feet	Mean Ft Sweat gm/11 hr	S.D.	t	P
1-30 31-60	79 94	11.86 15.70	± 4.993 ± 4.600	5.222	<.001
1-30 61-90	79 70	11.86 17.16	± 4.993 ± 3.761	7.367	<.001
1-30 91-120	79 41	11.86 15.97	± 4.993 ± 4.031	4.871	<.001
31-60 61-90	94 70	15.70 17.16	± 4.600 ± 3.761	2.234	<.001
31-60 91-120	94 41	15.70 15.97	± 4.600 ± 4.031	0.342	>.70
61-90 91-120	70 41	17.16 15.97	± 3.761 ± 4.031	1.538	>.10

6. Diurnal Foot-Sweat Measurements on Frostbite Patients

Diurnal measurements of foot sweat were made for 54 patients. These values were combined irrespective of degree of injury or extremity so that the mean grams of sweat collected per foot per 11 hours could be calculated.

Comparisons of these mean values were made on the basis of time post-injury that the collection was performed (Table 10). There was a progressive increase of foot sweat from the first period (1-30 days post-injury) to the fourth and last period (91-120 days). The mean foot sweat of the first period was significantly lower than the mean of any one of the other three intervals. The 31-60 day period mean was significantly lower than the mean of the 91-120 day period. The mean of the second period was not significantly different from the mean of the third period nor was the third period mean significantly different from that of the fourth period.

TABLE 10

COMPARISON OF MEAN FOOT SWEAT MEASUREMENTS OF DIURNAL COLLECTION FOR 54 PATIENTS WITH RESPECT TO TIME POST-INJURY

Days Post-Injury	No. of Feet	Mean Ft Sweat [illegible] 11 hrs	Standard Deviation	t	P
1-30 31-60	78 63	17.5 21.0	± 5.40 ± 8.42	2.360	<.01
1-30 61-90	78 22	17.5 24.1	± 5.40 ± 7.20	4.046	<.001
1-30 91-120	78 4	17.5 27.3	± 5.40 ± 4.60	4.143	<.001
31-60 61-90	63 22	21.0 24.1	± 8.42 ± 7.20	1.706	>.05
31-60 91-120	63 4	21.0 27.3	± 8.42 ± 4.60	2.509	<.02
61-90 91-120	22 4	24.1 27.3	± 7.20 ± 4.60	1.148	>.02

There was a progressive increase in the sweat production up to 90 days after injury for both the diurnal and

nocturnal measurements. Comparisons between the day and night values indicated a greater sweat output during the diurnal period (Table 11). This differential undoubtedly reflected the effects of greater physical activity of the patients during the daytime.

TABLE 11

COMPARISON OF MEAN FOOT SWEAT MEASUREMENTS FOR DIURNAL AND NOCTURNAL COLLECTIONS WITH RESPECT TO TIME POST-INJURY

Days Post-Injury	Time of Test	No. of Feet	Mean Ft Sweat gm/11 hr	Standard Deviation	t	P
1-30 1-30	Night Day	79 78	11.9 17.5	± 4.99 ± 5.40	6.745	<.001
31-60 31-60	Night Day	94 63	15.7 21.0	± 4.60 ± 8.42	4.561	<.001
61-90 61-90	Night Day	70 22	17.2 24.1	± 3.76 ± 7.19	4.320	<.001
91-120 91-120	Night Day	41 4	16.0 27.3	± 4.03 ± 4.60	4.781	<.001

7. Racial Comparison of Frostbite Patients

The mean foot-sweat values for the 25 White and 22 Negro patients were compared irrespective of specific extremity or degree of injury. No significant difference was found between the two groups ("t" = 0.524).

8. Contralateral Uninjured Feet in Unilateral Frostbite

There were eight patients who had either a second or third degree frostbite of one foot and the contralateral foot showed no overt evidence of injury by cold. Table 12 shows the individual mean foot-sweat values for these

eight patients in each post-injury period. It is to be noted that the mean of mean values for injured and uninjured feet are not too different and follow a progressive pattern up to 90 days after injury. Comparison between the mean of mean values for the injured and uninjured feet showed no significant differences in foot sweat collected during each post-injury period for these two classes of feet ("t" values ranged from 0.165 to 0.852).

The mean foot-sweat values for the contralateral uninjured feet were compared with respect to the different post-injury periods. The differences between the first and third and first and fourth periods were significant (Table 13). The remaining comparisons were not significant. Table 14 shows the comparison between the mean foot-sweat measurements for contralateral uninjured feet and frostbitten feet (population from Table 9). In no case was there a significant difference in foot sweat for these two distinct groups of feet.

9. Uninjured Feet in Frostbite of the Hands

Measurements of foot sweat were made for 15 patients who had frostbite of the hands without any overt evidence of cold injury to their feet. The mean grams of foot sweat collected from these patients for each post-injury period is shown in Table 15. Data for the 91-120 day period were not utilized because of the small size of the sample. The mean foot-sweat values were however of the same order as the 61-90 day period. The mean of mean

TABLE 12

DISTRIBUTION OF SWEAT VALUES FOR 8 PATIENTS WITH
UNILATERAL FROSTBITE OF THE FEET ACCORDING TO POST-INJURY COLLECTION PERIOD

Case No.	Classification of Feet*	Days Post-Injury							
		1-30		31-60		61-90		91-120	
		Mean Ft Sweat gms/11 hr	S.D.	Mean Ft Sweat gms/11 hr	S.D.	Mean Ft Sweat gms/11 hr	S.D.	Mean Ft Sweat gms/11 hr	S.D.
20	Right C*	7.53	± 2.159	[illegible]	± [illegible]	[illegible]	± 0.255	14.13	± 3.228
	Left 3*	7.48	± 2.350	12.72	± [illegible]	14.37	± 1.903	12.95	± 0.690
26	Right C*			15.53	± [illegible]	22.23	± 14.101	15.63	± 3.255
	Left 3*			15.60	± [illegible]	18.40	± 0.924	19.93	± 7.207
43	Right C*	7.27	± 0.303	[illegible]	± [illegible]	15.93	± [illegible]	[illegible]	± 2.179
	Left 3*	6.53	± [illegible]	[illegible]	± 1.676	15.20	± [illegible]	11.10	± 1.143
24	Right C*	11.70	± 3.191	15.97	± 9.312				
	Left 3*	11.90	± 2.703	19.60	± [illegible]				
32	Right 3*			21.82	± [illegible]	18.03	± 4.025	19.40	± 3.958
	Left C*			[illegible]	± [illegible]	20.50	± 4.309	17.54	± 4.265
49	Right 3*			[illegible]	± [illegible]	14.57	± [illegible]	15.23	± 2.785
	Left C*			17.74	± [illegible]	20.45	± 10.501	16.23	± 0.859
54	Right 3*	11.53	± 5.474	[illegible]	± [illegible]	[illegible]	± [illegible]		±
	Left C*	11.93	± [illegible]	[illegible]	± [illegible]	13.35	± 0.300		
66	Right C*	11.23	± 1.541	[illegible]	± [illegible]	[illegible]	± 3.159		
	Left 3*	[illegible]	± [illegible]	15.37	± 8.056	14.27	± 2.395		
Mean of Means	Injured	10.25	± 3.477	15.06	± 3.555	15.78	± 1.872	15.73	± 4.364
	Uninjured	9.93	± 2.602	14.01	± 4.163	17.21	± 4.025	14.87	± 2.887

C designates the contralateral uninjured foot.

TABLE 13

FOOT SWEAT RATE COMPARISONS BETWEEN POST-INJURY PERIODS FOR UNINJURED FEET OF PATIENTS WITH UNILATERAL FROSTBITE

Days Post-Injury	No. of Feet	Mean Ft Sweat gms/11 Hr	S.D.	t	P
1-30 31-60	5 8	9.93 14.01	± 2.602 ± 4.163	2.175	>.05
1-30 61-90	5 7	9.93 17.21	± 2.602 ± 4.025	3.801	<.01
1-30 91-120	5 5	9.93 14.87	± 2.602 ± 2.887	2.842	<.05
31-60 61-90	8 7	14.01 17.21	± 4.163 ± 4.025	1.512	>.10
31-60 91-120	8 5	14.01 14.87	± 4.163 ± 2.887	0.439	>.60
61-90 91-120	7 5	17.21 14.87	± 4.025 ± 2.887	1.173	>.20

TABLE 14

FOOT SWEAT RATE COMPARISONS BETWEEN PATIENTS WITH FROSTBITTEN FEET AND THE UNINJURED FEET OF PATIENTS WITH UNILATERAL FROSTBITE FOR THE POST-INJURY PERIODS

Feet	Days Post-Injury	No. of Feet	Mean Ft Sweat gms/11 Hr	S.D.	t	P
Frostbitten Uninjured*	1-30	79 5	11.86 9.93	± 4.993 ± 2.602	1.494	>.10
Frostbitten Uninjured*	31-60	94 8	15.70 14.01	± 4.600 ± 4.163	0.998	>.30
Frostbitten Uninjured*	61-90	70 7	17.16 17.21	± 3.761 ± 4.025	0.032	>.90
Frostbitten Uninjured*	91-120	41 5	15.97 14.87	± 4.031 ± 2.887	0.766	>.40

*Contralateral foot frostbitten

TABLE 15

DISTRIBUTION OF FOOT SWEAT VALUES FOR 15 PATIENTS WITH FROSTBITE OF THE HANDS AND NO COLD INJURY OF THE FEET ACCORDING TO POST-INJURY COLLECTION PERIOD

Subject No. and Feet		Days Post-Injury					
		1-30		31-60		61-90	
		Mean Ft Sweat gm/ 11 hrs	S.D.	Mean Ft Sweat gm/ 11 hrs	S.D.	Mean Ft Sweat gm/ 11 hrs	S.D.
13	Right	7.95	± 3.245	17.34	±17.693		
	Left	7.50	± 1.994	19.79	±16.569		
46	Right	9.83	± 3.931	14.50	± 4.118	18.30	± 2.549
	Left	9.43	± 3.624	15.22	± 4.505	19.93	± 2.756
51	Right	14.60	± 3.162	15.20	± 4.800		
	Left	14.03	± 3.537	13.90	± 3.000		
56	Right	12.80	± 3.345	13.10	± 1.761	15.63	± 6.047
	Left	11.90	± 3.132	12.95	± 0.763	14.40	± 4.867
59	Right	13.67	± 3.929	16.54	± 2.534	15.33	± 2.596
	Left	20.47	± 9.676	15.92	± 2.507	14.47	± 2.573
61	Right	13.73	± 3.443	13.40	± 3.323	11.53	± 1.991
	Left	16.00	± 3.320	15.13	± 2.003	14.07	± 2.950
62	Right	11.53	± 3.695	9.03	± 4.651	23.80	±30.179
	Left	14.53	± 6.015	13.62	± 4.322	13.67	±10.049
69	Right	15.50	±11.333	15.82	± 2.513	14.17	± 4.229
	Left	13.50	± 2.972	16.63	± 5.726	15.97	± 1.922
74	Right	11.77	± 3.994	10.33	± 2.193	11.13	± 3.229
	Left	11.60	±12.856	12.13	± 2.533	10.20	± 4.472
76	Right	12.95	± 2.100	12.97	± 1.690		
	Left	13.10	± 1.766	11.80	± 0.403		
77	Right	10.53	± 1.251	12.33	± 1.623		
	Left	10.37	± 0.971	12.55	± 3.003		
78	Right	14.43	± 4.247	13.46	± 1.902		
	Left	6.90	± 7.927	13.03	± 0.523		
80	Right	14.55	± 1.793	14.65	± 0.917		
	Left	13.40	± 2.769	14.50	± 2.018		
89	Right	11.75	± 6.300	11.76	± 4.906		
	Left	16.00	± 3.400	10.94	± 2.820		
94	Right	13.70	± 2.800	13.10	± 3.270		
	Left	12.75	± 0.320	12.45	± 1.153		
Mean of Means	Right Foot	12.62	± 2.134	13.63	± 2.187	16.41	± 6.474
	Left Foot	12.79	± 3.582	14.03	± 2.344	14.53	± 3.231

values for these cases was initially slightly higher than that for feet with first and second degree frostbite (Tables 2, 3, 5, 6) but a progressive increase from 1-30 to 61-90 days still existed. The difference in foot-sweat values between these uninjured right and left feet within each post-injury collection period were not significant ("t" values ranged from 0.158 to 0.687). The sweat values for each foot were combined according to the different post-injury periods. In comparisons of foot-sweat values for the different periods no significant differences were found (Table 16). These data show that the increase in foot sweat post-injury was not present as in the case of feet injured by cold.

TABLE 16

FOOT SWEAT RATE COMPARISONS BETWEEN POST-INJURY PERIODS OF UNINJURED FEET OF PATIENTS WITH FROSTBITE OF THE HANDS

Days Post-Injury	No. of Feet	Mean Ft Sweat gm/ 11 hr	S.D.	t	P
1-30 31-60	30 30	12.70 13.85	± 2.753 ± 2.128	1.810	>.05
1-30 61-90	30 14	12.70 15.47	± 2.753 ± 4.830	1.999	>.05
31-60 61-90	30 14	13.85 15.47	± 2.128 ± 4.830	1.202	>.20

Table 17 shows the comparisons between the foot-sweat values for feet with frostbite and those for uninjured feet of patients with frostbite of the hands. The amount of foot sweat collected in these two groups was not significantly

different except in the 31-60 post-injury period, where less sweat was collected from the uninjured feet.

TABLE 17

COMPARISON OF FOOT SWEAT RATES FOR PATIENTS WITH FROSTBITTEN FEET AND UNINJURED FEET OF CASES WITH FROSTBITTEN HANDS FOR EACH POST-INJURY PERIOD

Feet	Days Post-Injury	No. of Feet	Mean Ft Sweat gm/11 hr	S.D.	t	P
Frostbitten Uninjured	1-30	79 30	11.86 12.70	± 4.993 ± 2.753	1.115	>.20
Frostbitten Uninjured	31-60	94 30	15.70 13.85	± 4.600 ± 2.128	3.016	<.01
Frostbitten Uninjured	61-90	70 14	17.16 15.47	± 3.761 ± 4.930	1.236	>.20

Analyses were made of the foot-sweat data for contralateral uninjured feet and uninjured feet of patients with frostbitten hands (Table 18). The differences in foot sweat between these two groups of feet were not significant except in the 1-30 post-injury period.

The above analyses indicated that the feet (patients with frostbitten hands) which presented no overt evidence of injury by cold had a smaller sweat output than frostbitten feet, which also did not increase with time post-injury. It also must be remembered that these feet, although not showing evidence of cold injury, nevertheless underwent a cold exposure which was severe enough to produce frostbite of the upper extremity in the same subject.

TABLE 18

COMPARISONS OF FOOT SWEAT RATES BETWEEN PATIENTS WITH CONTRALATERAL UNINJURED FEET AND THE UNINJURED FEET OF CASES WITH FROSTBITTEN HANDS FOR EACH POST-INJURY PERIOD

Uninjured feet-source	Days Post-Injury	No. of Feet	Mean Ft Sweat gms/ 11 Hr.	S.D.	t	P
Hand Cases Feet Cases*	1-30	30 5	12.70 9.93	± 2.753 ± 2.602	2.186	<.05
Hand Cases Feet Cases*	31-60	30 8	13.85 14.01	± 2.128 ± 4.163	0.105	>.90
Hand Cases Feet Cases*	61-90	14 7	15.47 17.21	± 4.830 ± 4.025	0.872	>.30

*Unilateral frostbite of feet, using contralateral uninjured foot

10. Osaka Controls

Nocturnal foot-sweat measurements of the Osaka controls yielded values for the right and left foot of 14.0 and 13.9 grams per 11 hours, respectively ("t" value of 0.276 and a P >.90). The mean foot sweat collected for 48 feet was 14.0 grams. In each post-injury period there was a significant difference in the mean sweat values of the Osaka controls and the patients with frostbite of the feet (Table 19). The control subjects had a greater sweat output than the 1-30 post-injury period cases which indicated the presence of a hypohidrotic state in the frostbitten feet. After 31 days post-injury the sweat output of the injured feet was significantly higher than that of the controls. Therefore, somewhere between 30 and 60 days after injury the frostbitten feet become hyperhidrotic which persisted for at least 120 days.

TABLE 19

COMPARISON OF FOOT SWEAT RATES BETWEEN
OSAKA CONTROLS AND PATIENTS WITH FROSTBITTEN FEET FOR
EACH POST-INJURY PERIOD

Feet	No. of Feet	Mean Ft Sweat gm/11 Hr.	S.D.	t	P
Osaka Controls	48	14.00	± 3.292		
vs					
Frostbitten 1-30	79	11.86	± 4.993	2.909	<.01
31-60	94	15.70	± 4.600	2.532	<.02
61-90	70	17.16	± 3.761	4.831	<.001
91-120	41	15.97	± 4.031	2.497	<.02

The sweat value for the Osaka controls was significantly higher than the value for the contralateral uninjured feet in the 1-30 post-injury period (Table 20). In the 31-60 period the sweat values for the two groups of feet were almost identical. In the 61-90 day period the contralateral uninjured feet had a significantly higher value than the controls. In the last post-injury period (91-120) the sweat values of the two groups were again similar and not significantly different.

Comparisons were made between the foot-sweat values for the Osaka controls and the uninjured feet of patients with frostbite of the hands (Table 21). Regardless of the post-injury period there were no significant differences between these two groups of feet. It would appear that the cold exposure which produced an injury of the hands did not markedly alter the sweating mechanism of the subjects feet as determined by this method.

TABLE 20

FOOT SWEAT RATE COMPARISONS BETWEEN OSAKA CONTROLS AND CONTRALATERAL UNINJURED FEET OF PATIENTS WITH FROSTBITE FOR EACH POST-INJURY PERIOD

Feet		No. of Feet	Mean Ft Sweat gms/ 11 Hr.	S.D.	t	P
Osaka Controls		48	14.00	± 3.292		
vs						
Uninjured*	1-30	5	9.93	± 2.602	3.238	<.01
	31-60	8	14.01	± [illegible].163	0.006	>.90
	61-90	7	17.21	± 4.025	2.014	<.05
	91-120	5	14.67	± 2.637	0.632	>.50

*Contralateral foot had frostbite

TABLE 21

FOOT SWEAT RATE COMPARISONS BETWEEN OSAKA CONTROLS AND UNINJURED FEET OF PATIENTS WITH FROSTBITE OF THE HANDS FOR EACH POST-INJURY PERIOD

Feet		No. of Feet	Mean Ft Sweat gms/ 11 Hr	S.D.	t	P
Osaka Controls		48	14.00	± 3.292		
vs						
Uninjured*	1-30	30	12.70	± 2.753	1.879	>.05
	31-60	30	13.85	± 2.123	0.244	>.80
	61-90	14	15.47	± 4.830	1.069	>.20
	91-120	4	15.10	± 0.672	1.890	>.05

*Patients with only frostbite of hands

11. Knox Controls

The 24 Knox control subjects had a sweat output for the right and left foot of 13.3 and 13.1 grams per 11 hours, respectively. Comparison of those two values gave a "t" of 0.524 and a P >.60. The mean sweat collected for 192 feet was 13.2 grams. Comparisons between the foot-sweat value for the Knox controls and the frostbitten feet by

post-injury period are shown in Table 22. The Knox controls had a significantly higher sweat output than the frostbite patients of the 1-30 day post-injury period which again indicated the presence of a hypohidrotic state in the frostbitten feet. From 31 to 120 days post-injury the foot-sweat values for the injured feet were all significantly higher than that for the control feet. These analyses imply that the cold injured feet became hyperhidrotic sometime between 30 and 60 days after injury. This finding corroborated the results obtained using the Osaka controls.

TABLE 22

FOOT SWEAT RATE COMPARISONS BETWEEN KNOX CONTROLS AND PATIENTS WITH FROSTBITE OF THE FEET ACCORDING TO POST-INJURY PERIOD

Feet	No. of Feet	Mean Ft Sweat gm/[illegible] Hrs.	S.D.	t	P
Knox Controls	192	13.22	± 2.381		
vs					
Frostbitten 1-30	79	11.86	± 4.993	2.315	<.05
31-60	94	15.70	± 4.600	4.915	<.001
61-90	70	17.16	± 3.761	8.123	<.001
91-120	41	15.97	± 4.031	4.214	<.001

The contralateral uninjured feet had a significantly lower foot-sweat output in the first post-injury period as compared to the Knox control feet (Table 23). During the 31-60 day period the two groups of feet had a similar sweat output. Between the 60th and 90th day post-injury the sweat output of the contralateral uninjured feet was

significantly higher than that for the control feet. No significant difference, however, was found between the control feet and the uninjured feet in the 91-120 day post-injury period. It would appear that the cold exposed contralateral uninjured feet underwent an alteration of their sweating mechanism that was not as marked or lasting as in the case of frostbitten feet.

TABLE 23

FOOT SWEAT RATE COMPARISONS BETWEEN KNOX CONTROLS AND CONTRALATERAL UNINJURED FEET OF PATIENTS WITH A UNILATERAL FROSTBITE

Feet		No. of Feet	Mean Wt Sweat gms/ 11 Hr.	S.D.	t	P
Knox Controls		192	13.22	± 2.[illegible]31		
vs						
Uninjured*	1-30	5	9.93	± 2.60[illegible]	2.[illegible]7	<.01
	31-60	8	14.01	± 4.163	0.553	>.50
	61-90	7	17.21	± 4.035	2.[illegible]5	<.01
	91-120	5	14.67	± 2.[illegible]37	1.257	>.20

*Contralateral foot had frostbite

Comparisons of foot-sweat values made between the Knox controls and uninjured feet of cases with frostbite of the hands yielded no significant differences (Table 24). This finding corroborated the results obtained using Osaka controls.

Comparison between the foot-sweat values of the Osaka and Knox control subjects showed no significant difference ("t" = 1.544, P >.10)

TABLE 24

FOOT SWEAT RATE COMPARISONS BETWEEN KNOX CONTROLS AND UNINJURED FEET OF PATIENTS WITH FROSTBITE OF THE HANDS

Feet	No. of Feet	Mean Ft Sweat gms/11 Hr.	S.D.	t	P
Knox Controls	192	13.22	± 2.381		
vs					
Uninjured* 1-30	30	12.70	± 2.753	0.979	>.30
31-60	30	13.85	± 2.128	1.433	>.10
61-90	14	15.47	± 4.830	1.723	>.05

*Hand Cases

12. Measurements of Skin Resistance

Only the data for patients with a similar bilateral degree of severity were analyzed. The data available included five second degree, four third degree and five fourth degree patients. An analysis of variance was made for each degree. The main sources of variation which were considered included the subjects (S), the four time intervals post-injury (T), the two lower extremities (E) and the six general areas of the foot (P) as described under Methods (II C). The analyses for each degree revealed that there were significant differences in the skin resistance measurements between the subjects, between the four time intervals and between the six positions utilized. The magnitude of the mean square value of subjects (S) indicated that the difference in skin resistance from one patient to the next greatly exceeded the differences resulting from the other factors enumerated. The interactions also showed that the subjects

varied independently with time and position. Because of the extreme subject variability no further comparisons were made.

IV. DISCUSSION

The over-all mean foot-sweat output for patients with first, second and third degree frostbite was approximately of the same magnitude. In many patients the frostbite lesions were confined to a single toe, with the majority of the foot apparently uninjured. For example, a patient might have a second degree lesion of the medial aspect of the great toe plus a first degree of the distal third of the foot with the remainder of the extremity uninjured. Likewise, a patient would have a third degree frostbite of the distal phalanx of the first and second toes, and the proximal two-thirds of the extremity would appear normal. The total number of sweat glands of the foot affected by cold injury in these cases must have been small and presumably would not have altered the over-all sweat output of the entire part. In this study, patients with extensive tissue damage were not separated on the basis of area involvement from those cases of like degree who had little tissue involvement. The grouping of cases on the basis of degree of severity but not taking into account area involvement may have masked alterations in foot-sweat output hence the similar values for all three degrees of injury.

The finding that frostbitten and uninjured feet of a single patient had essentially the same mean sweat output might also be a reflection of the small number of sweat glands injured by cold.

The plantar surface of the foot contains many sweat glands which primarily respond to emotional stimuli. The dorsum of the foot

is supplied with fewer sweat glands which respond primarily to heat stimulation (9). It is recognized that psychic influences, being uncontrolled in this study, could have influenced the sweat measurements of all the subjects. No attempt was made to evaluate the influence of the emotional factors.

The lack of significant differences in foot-sweat output between the White and Negro patients was interesting in view of Clark's and Lhamon's (10) sweat gland counts of the skin of the plantar surface of the foot and the palmar surface of the hand for these two races. It appears that although there is a difference in the number of sweat glands present in the feet of the United States White and Negro races, this difference may not be great enough to produce significant variations of foot-sweat output as measured by the method employed in this study.

The innervation of the sweat glands is well known. They are supplied by nerve fibers which are sympathetic in structure but cholinergic in action. The sympathetic fibers to the sweat glands of the lower extremities arise from the thoracic and upper lumbar segments. A bilateral lumbar sympathectomy performed for hyperhidrosis of the feet usually results in a loss of sweating in the lower extremities.

In this study of frostbite the presence of a true anhidrotic phase was not clearly defined since no conclusions could be made on the basis of five anhidrotic patients (see III A). These five patients may represent the extreme. In first, second and third degree frostbite there may be direct damage to the sweat glands by cold, but a depression of activity in the local sympathetic nervous system within the

foot itself seems a more feasible explanation. This depression of sympathetic activity resulting from cold causes a reduction in foot-sweat output which lasts for at least 30 days after injury. The mechanism of the depression may be similar to that exerted by a sympathetic procaine block. The progressive increase in sweat output from 31 to 90 days after injury might represent a rebound phenomenon in the sympathetic activity either through a release of, or recovery from, the earlier depressant effect of cold. It would appear that in first, second and third degree frostbite of the feet, even though the sweat gland might not be damaged by cold, the activity of the sympathetic innervation of the gland might have been altered. Similar alterations, but to a lesser extent, were indicated in the foot-sweat rates of contralateral uninjured feet of patients with unilateral frostbite and uninjured feet of cases with frostbitten hands. In the former group the effect of the cold on the feet was undoubtedly more pronounced than in the latter group since one foot of the subject was frostbitten. In the latter group, with bilaterally uninjured feet, the sweat rates more nearly approximated the values of the control subject than the values for frostbitten feet or those of contralateral uninjured feet.

On the basis of comparison of the mean foot-sweat values for the controls and the frostbite patients it would appear that a state of hyperhidrosis of the frostbitten foot develops somewhere between the 30th and 60th day after injury. How long beyond 120 days post-injury this hyperhidrotic state persists has not been determined yet. This state of hyperhidrosis was present in all three degrees of frostbite and to a lesser extent in the cold exposed but uninjured feet.

Although a true state of anhidrosis was not established for the majority of the patients studied, the early foot-sweat values when compared to those of the Osaka and Knox controls showed a significant degree of hypohidrosis. This would suggest that very early after injury anhidrosis might be present.

The Osaka controls approached the frostbite patients as a similar population in that they also were hospitalized and were semi-ambulatory, although the relative degree of ambulation between the two groups was difficult to determine. The Fort Knox controls more nearly satisfy the criteria for a truly normal population. In this latter group, however, rigid restriction of activity to the degree encountered among the frostbite patients was not maintained except during the test hours. Assuming that any difference in activity between the two groups was small it appears that the hyperactivity of the sweat glands in the feet of the frostbite cases was real.

Skin resistance measurements were made in an attempt to provide additional objective evidence of the degree of hyperactivity of the sweat glands. The measurement of skin resistance may be an indication of the amount of underlying sweat gland activity only for the immediate area to which the electrode is applied. Some of the inherent difficulties in using the dermometer were: the exploring electrode was sensitive to manual pressure, rotation of the axis of the electrode on a given point resulted in different values and the repeated placing of the electrode on a given point resulted in different values of skin resistance. To minimize these errors only one technician took the measurements throughout the study. This technician attempted to use the same degree of pressure on all points keeping the axis of the

electrode constant from point to point. Because of the above technical difficulties and the extreme variability of the skin resistance data as shown in an analysis of variance of the different factors, it was concluded that such measurements by this technique were not of value in this study.

V. SUMMARY AND CONCLUSIONS

Results of the Minor Starch-Iodine test on 78 patients, five of whom were initially anhidrotic were reported. Foot-sweat measurement studies were presented for first, second and third degree frostbite patients. Comparisons were made among patients having frostbite of one foot and no involvement of the other foot and cases with uninjured feet but frostbitten hands. The results of foot-sweat determinations on 48 controls were discussed. The relationship between extent of area of tissue damage, irrespective of clinical degree of frostbite, and alterations in sweat output was discussed. The factor of racial differences in sweat output was considered. Results of skin resistance studies on second, third and fourth degree patients were discussed.

The conclusions of this study were as follows:

1) The sweat output for the right and left feet of all subjects was not significantly different.
2) The amount of foot sweat collected was not significantly altered by the degree of frostbite.
3) The foot-sweat rates for frostbitten feet varied directly from time post-injury up to 90 days.
4) The diurnal foot-sweat rates for frostbitten feet were higher than the nocturnal measurements.

5) The foot-sweat measurements for White and Negro patients were not significantly different.

6) The foot-sweat measurements for patients with bilateral frostbite and patients with contralateral uninjured feet were not significantly different.

7) When compared to the Osaka and Knox controls the frost-bitten feet were hypohidrotic for the first 30 days after injury and hyperhidrotic from 31 days to at least 120 days.

VI. RECOMMENDATIONS

It is recommended that future studies of the mechanism of sweating following a cold injury should determine:

1. The extent to which sweat glands may be damaged and the rate of recovery of secretory activity for the different degrees of frostbite.

2. The relationship between sympathetic nerve injury and alterations in sweat gland activity for all degrees of frostbite.

3. The effect of vapor barriers in relation to suppression and/or reabsorption of sweat.

VII. BIBLIOGRAPHY

1. Ungley, C. C. Peripheral vasoneuropathy after chilling. Lancet. 2: 447-461, 17 October 1942.

2. Davis, L. D., J. E. Scarff, N. Rogers and M. Dickinson. High altitude frostbite. Surg., Gynec. & Obst. 77(6): 561-575, December 1943.

3. Wadsworth, R. C. and B. V. Whitney. The pathology and therapy of frostbite. J. Main M. A. 345-350, December 1948.

4. Friedman, N. B. and R. A. Kritzler. The pathology of high altitude frostbite. Am. J. Path. 23(2): 173-187, March 1947.

5. Minor, V. Ein neues Verfahren zu der Klinischen Untersuchung der Schweissabsonderung. Deutsche Ztschr. f. Nervenh. 101: 302-308, 1928.

6. Richter, C. P. and B. G. Woodruff. Changes produced by sympathectomy in the electrical resistance of the skin. Surgery. 10: 957-970, 1941.

7. ________________. Facial patterns of electrical skin resistance. Bull. John Hopkins Hosp. 70: 442-459, 1942.

8. ________________. Lumbar sympathetic dermatomes in man determined by the electrical skin resistance method. J. Neurophysiol. 8: 323-338, 1945.

9. Folk, G. E., Jr. and R. E. Peary. Experiments on the physiology of foot perspiring. Special Report SR No. 37, Environmental Protection Section, OQMG, 22 May 1950.

10. Clark and Lh[illegible]. Sweat gland counts for skin. Anat. Rec. 12: 139, 1917.

ARMY MEDICAL RESEARCH LABORATORY

FORT KNOX, KENTUCKY

REPORT NO. 113
1 April 1953

COLD INJURY - KOREA 1951-52*

Section XI
COLD STRESS STUDIES ON POST-FROSTBITE PATIENTS
Part I - Skin Color Changes

*Subtask under Environmental Physiology, AMRL Project No. 6-64-12-028, Subtask (SK), Cold Injury Studies.

MEDICAL RESEARCH AND DEVELOPMENT BOARD
OFFICE OF THE SURGEON GENERAL
DEPARTMENT OF THE ARMY

SECTION XI

COLD STRESS STUDIES ON POST-FROSTBITE PATIENTS

PART I: Skin Color Changes

by

Coleman D. Caplovitz
1st Lt. MC, USAF

TABLE OF CONTENTS

COLD STRESS STUDIES ON POST-FROSTBITE PATIENTS

PART I: Skin Color Changes

I. INTRODUCTION

It has been noted in the past that patients who had sustained injury of their extremities due to cold were thereafter abnormally sensitive to re-exposure to low ambient temperatures. This series of observations was undertaken to study and record the objective changes in the skin of a previously frostbitten extremity when that extremity was exposed to low environmental temperatures, and to observe the effect of various sympatholytic agents on these changes.

II. METHODS

The study group was comprised of 72 United States soldiers who had incurred a frostbite injury between 23 November and 20 December 1951. From the time of initial evacuation until the initiation of the cold stress studies the patients were confined to the environment of a hospital ward, where the ambient temperature ranged between 70° and 78° F. All subjects were ambulatory and their frostbite lesions were healed, in that intact viable skin covered the former sites of frostbite. The ages of the test patients ranged from 18 to 26 years. The length of hospitalization for the members of the study groups as of 16 January 1952 ranged from 30 to 50 days. Seventy-two patients were observed between 16 January 1952 and 15 April 1952 for a total of 325 exposures to an environmental temperature of 50° F. Of the 72 patients, 33 were Caucasian, 35 Negro, and four Puerto Rican or Latin American. For technical reasons these have been combined into two groups, non-

pigmented (Caucasians) and pigmented (Negroes plus Puerto Ricans and Latin Americans). The distribution of these two groups according to site and maximum degree of injury is shown in Tables 1 and 2.

TABLE 1

DISTRIBUTION OF 33 NON-PIGMENTED FROSTBITE PATIENTS WITH RESPECT TO SITE AND MAXIMUM DEGREE OF INJURY

Max. Degree of Injury	Feet - 26 Patients		Hand - 7 Patients	
	No. of Patients	No. of Digits Injured by Degree	No. of Patients	No. of Digits Injured by Degree
No Injury	—	100	—	26
First	1	102	—	14
Second	13	37	6	29
Third	12	21	1	1
TOTAL	26	260	7	70

TABLE 2

DISTRIBUTION OF 39 PIGMENTED FROSTBITE PATIENTS WITH RESPECT TO SITE AND MAXIMUM DEGREE OF INJURY

Max. Degree of Injury	Feet - 25 Patients		Hand - 14 Patients	
	No. of Patients	No. of Digits Injured by Degree	No. of Patients	No. of Digits Injured by Degree
No Injury	—	69	—	20
First	2	128	—	62
Second	10	35	10	49
Third	1[illegible]	18	4	9
TOTAL	25	250	14	140

These patients after being exposed for the first time when the lesions were covered by new intact viable skin, were re-exposed to the cold at intervals of 5 to 14 days for the duration of their hospitalization. The cold exposure observations ranged from 3 to 20 weeks

post-injury. Some patients were exposed only once while others underwent 12 to 14 exposures.

The patients were clad in cotton pajamas and were placed supine on stretchers padded by two folded blankets (eight layers) and a sheet. They were covered by a single sheet and a single blanket from their chins to midway between the knee and ankle. Those having had frostbite of the hands also had their arms (from the shoulder down) outside of the blanket, with their pajama sleeves extending to the middle of the forearms. Feet as well as hands were observed in these cases. All subjects were allowed to equilibrate at a room temperature of 68° to 77° F. for one hour. They were transferred then to a constant temperature room previously stabilized at 48 to 52° F. and left there for 1-1/2 hours. Following the cold exposure the subjects were returned to the pretest environment and observed for three additional hours. Observations included:

1) Clinical observations with respect to the type and degree of color change noted in each digit.
2) Oral temperatures just prior to entering cold room.
3) Oral temperatures just prior to leaving cold room.
4) Oral temperatures 1-1/2 hours after leaving cold room.

The color observations during room temperature exposure were made in indirect sunlight and during the cold exposure artificial light was employed. Subjective sensations were recorded only when they were mentioned spontaneously by the patient. It should be mentioned that observations on the darker pigmented patients were, necessarily, restricted by the pigment, but frequently areas of de-

pigmentation were present at sites of previous lesions, facilitating observation. Subjects were kept supine throughout the procedure and were transported to and from the cold room on the same stretcher on which they lay during the entire time. All observations of color changes were made by the same observer.

In an attempt to standardize the classification of clinical response to cold as observed, an arbitrary gradation of color change was used in the results to be described below. Three types of discoloration were noted; pallor, cyanosis and a color considered to be a combination of pallor and cyanosis and designated as graynoss. Since all three of these were believed to be evidence of vasospasm in one or another portion of the pre-capillary or post-capillary vascular tree, they were considered together in the analysis as simply deviations from the normal pink color of well vascularized skin. The color deviations were then broken down into three groupings according to severity of response, i.e. mild, moderate or marked, and were further broken down according to the exposure time necessary to bring about that change. The gradation in "maximum test color" response can therefore be defined as follows, in what was considered declining order of severity:

1) Marked color deviation occurring during first half hour of exposure.
2) Marked color deviation during second half hour of exposure.
3) Marked color deviation during last half hour of exposure.
4) Moderate color deviation during first half hour.

5) Moderate color deviation during second half hour.

6) Moderate color deviation during last half hour.

7) Slight color deviation during first half hour.

8) Slight color deviation during second half hour.

9) Slight color deviation during last half hour.

10) No color deviation from pink or flushed.

When data were small in number of cases or when the time factor had to be omitted, as with evaluation of drugs given after the patient had entered the cold room, groups 1, 2 and 3 were combined as simple "marked deviation", groups 4, 5 and 6 as "moderate deviation" and groups 7, 8 and 9 were combined as "slight deviation". Group 10 formed the fourth category of "no change".

Technical difficulties encountered in the performance of the cold stress studies included:

1) Difficulty in mixing the air in the test chamber to avoid local temperature variations without encountering the factor of increased windchill in certain areas.

2) Difficulty in obtaining optimal lighting conditions for evaluation of skin color without producing excessive heating of the room (Fluorescent lighting is not desirable because of the dusky hue it imparts to normally pink skin and mucous membrane).

3) The obvious human error of grading color change was not a small one. It would be advantageous to have a more objective method.

In addition to the control observations (cold exposure obser-

vations uninfluenced by drugs or sympathetic blocks) randomly selected patients were given either intravenous injections of priscoline, hexamethonium or a unilateral lumbar sympathetic block just prior to entering the cold chamber. One of these drugs or the sympathetic block was used to produce vasodilatation and possibly alter the pattern of skin changes. A group of 11 patients was given a 25 day course of hexamethonium in the dose of 50 mgm. intramuscularly every 6 hours. They were observed in the cold room on a control run immediately prior to onset of therapy, twice during the course of therapy and, when possible, a week after cessation of therapy. Another group of 11 patients was similarly observed during a 25 day course of priscoline (50 mgm.) administered orally four times a day. Every determination was done during the same hours of the day (0730 to 1430) and with the same relation to meals. Each test subject was restricted to the hospital after 1700 hours the day prior to testing. The number of cigarettes smoked by the patient prior to testing was not restricted but that number was recorded. No smoking was permitted during the procedure or the equilibration period before or after the procedure. Movement of the extremities and body by the patient was strongly and consistently discouraged during the test procedure, but could not be universally prevented.

III. RESULTS

Of the 325 determinations analyzed, 149 were controls, 30 were determinations influenced by unilateral lumbar sympathetic blocks, 80 were determinations in which hexamethonium was used and 66 were determinations in which priscoline was employed. These will be evaluated

separately.

A. General

Pain was a relatively insignificant corollary of the exposure to cold. Many patients only complained of pain when specifically questioned. Their discomfort usually was manifested as a sensation of general aching or paresthesias ("tingling" or "needles and pins") of a digit or of the entire distal portion of an extremity. On the other hand, pain was sufficiently severe to cause a spontaneous unelicited complaint from 24 of the 72 patients and during only 36 procedures of the 325. When discomfort was mentioned by the patient, however, a highly significant relationship was demonstrable between the location of the pain and the severity of color deviation at that site. Table 3 shows this relationship by comparing the color deviation of the digits causing pain with the color deviations of the remaining digits on the same or opposite extremity of the same patient during the same test procedure. It is worthy of note, however, that 58 digits without obvious color change were painful.

TABLE 3

COMPARISON OF MAXIMUM COLOR RESPONSE WITH PAIN IN DIGITS UNDER COLD STRESS

Maximum Color Response	Total Digits	Digits with Pain	Digits without Pain*
No Change	155	58	97
Slight	61	30	31
Moderate	53	37	16
Marked	37	35	2
TOTAL	325	180	145
chi square = 48.9777			
P <.01			

* Digits in the same patient who complained spontaneously of pain in other digits.

Similarly, a definite relationship was established between the severity of injury of the digit and the site of pain. In other words, when a digit caused pain on exposure to cold, it was more apt to have been previously involved in third degree frostbite than in second degree, and more apt to have been second degree than first degree or uninjured. This is shown in Table 4. It is to be noted again, however, that 27 digits that were uninjured were painful. It is believed that these uninjured digits causing pain and the previously mentioned painful digits showing no color change can be easily explained by the poor localization of pain by the patient.

TABLE 4

COMPARISON OF DEGREE OF FROSTBITE WITH PAIN IN DIGITS UNDER COLD STRESS

Degree of Frostbite	Total Digits	Digits with Pain	Digits without Pain*
No Injury**	83	27	56
First Degree	175	81	94
Second Degree	83	64	19
Third Degree	19	17	2
TOTAL	360	189	171
chi square = 7.1503 P <.01			

* Digits in the same patient who complained spontaneously of pain in other digits.
** Non-injured digits in frostbitten subjects.

When the patient complained that the entire foot and all toes ached, this was recorded as pain in all digits - thereby occasionally including non-injured and non-cyanotic digits together with the injured and cyanotic ones. In spite of

this error, the figures proved to be significant when subjected to the chi square test.

B. Control Determinations

Of the 149 control procedures, 14 determinations were made on the hands of non-pigmented patients, 48 on the feet of non-pigmented patients, 24 on the hands of pigmented patients and 63 on the feet of pigmented patients. These control observations were interspersed between determinations using various drugs and procedures, and they represent a follow-up of certain patients over the entire period of the 13 weeks during which these tests were performed. The tests were performed from 3 to 20 weeks post-frostbite with a mean of 10.1 $\pm$ 3.2 weeks. There was no correlation between the severity of color change and the time post-frostbite at which the procedure was performed.

Data were obtained on 112 procedures regarding the number of cigarettes smoked during the period of time between the hour at which the patient arose and the time of the test. The range of cigarettes smoked was from zero to five cigarettes, with 97 of the 112 (or 87%) having smoked two cigarettes or less. No correlation was established between the number of cigarettes smoked prior to testing either for the pigmented and non-pigmented groups or the severity of the color response to cold.

In order to correlate the degree of frostbite with the severity of color response to cold, the control data were

selectively analyzed. Since, as mentioned before, the uninjured digits were difficult to evaluate in the pigmented patient (previously injured digits had depigmented areas whereas the uninjured digits had no such areas), these patients were excluded from this evaluation. Since there were too few hand cases in the non-pigmented group to be analyzed alone, these were also discarded from this analysis. Instead, the data obtained from observing the feet of these hand cases were added to that obtained from the non-pigmented foot cases in order to increase the number of uninjured digits analyzed. Thus the analysis was of the feet of 62 non-pigmented patients and thereby included 620 individual digits varying in degree of injury from none to third degree. There was no significant correlation demonstrated between degree of injury and severity of color response in the third, fourth and fifth digits. This is readily explainable if it is noted that almost all of those digits were uninjured or had sustained only first degree lesions. Only 11 of these 372 digits had had second degree lesions, and only two had had third degree lesions. Furthermore, since these minimally injured digits were, in many cases, on the same extremity with more severe lesions, little attention was given to them, and the distinction between first degree frostbite and no frostbite at all was questionable in many instances. Thus, the lack of correlation is not unexpected. On the other hand, the first and second toes, which were the more severly frostbitten

digits, showed a highly significant correlation between the degree of injury and the severity of color response to cold as demonstrated in Table 5.

TABLE 5

CORRELATION BETWEEN DEGREE OF FROSTBITE AND MAXIMUM COLOR RESPONSE OF DIGITS UNDER COLD STRESS*

Degree of Frostbite	Total Digits	Maximum Color Response			
		Digits with no Change	Digits with Slight Change	Digits with Moderate Change	Digits with Marked Change
Great Toes					
No Injury**	32	8	10	13	1
First Degree	34	4	13	13	4
Second Degree	35	2	8	10	15
Third Degree	23	3	5	7	8
Total	124	17	36	43	28
Coefficient of Correlation = 0.3010 P <.01					
Second Toes					
No Injury**	54	30	22	2	0
First Degree	46	14	20	8	4
Second Degree	12	5	0	4	3
Third Degree	12	1	5	3	3
Total	124	50	47	17	10
Coefficient of Correlation = 0.4343 P <.01					

* White patients - control determinations only
** Non-injured digits in frostbitten subjects

C. Lumbar Sympathetic Block

Thirty unilateral lumbar sympathetic blocks were performed on 27 patients, blocking the sympathetic ganglia at L-1 and L-2 with a combination of procaine and pontocaine. Three of these were considered unsuccessful blocks in that they failed to produce the expected warming and drying of the blocked extremity, and repetition of the block on the same individual

was more satisfactory at a subsequent date. All blocks were performed from 5 to 20 minutes prior to entering the test chamber. Of the 27 successful blocks, 12 were of the right and 15 were of the left lumbar sympathetic chain. Eleven were performed on non-pigmented patients, and 16 were performed on pigmented patients. Three of the patients showed no significant color response to cold during their control test, so could not be expected to derive benefit in that respect from the block. Table 6 compares the maximum color changes of the remaining 24 cases during control determinations with the maximum color response that developed in the blocked extremity during exposure to cold. It should be noted that in all cases but one in which a color change occurred, it took place during the last half hour of exposure. It was quite likely that some of these occurred after the effective period of the sympathetic block. In spite of this possible error, the statistics remained highly significant when subjected to the "t" test.

A significant side effect of the vasodilatation which occurred in an extremity during sympathetic block is demonstrated in Table 7. It compares the change in oral temperature (difference between pretest oral temperature and oral temperature taken just prior to leaving the cold room) that occurred in control determinations with that which occurred when a lumbar sympathetic block was performed

TABLE 6

COMPARISON OF COLOR RESPONSE TO COLD STRESS WITH AND WITHOUT A LUMBAR SYMPATHETIC BLOCK

Maximum Color Response*		Total Patient Tests	Control**	Blocked Extremity***
Marked Change	(during 1st half hour (1))	0	0	0
	(during 2nd half hour (2))	7	7	0
	(during 3rd half hour (3))	6	4	2
Moderate Change	(during 1st half hour (4))	0	0	0
	(during 2nd half hour (5))	4	4	0
	(during 3rd half hour (6))	11	4	7
Slight Change	(during 1st half hour (7))	2	1	1
	(during 2nd half hour (8))	0	0	0
	(during 3rd half hour (9))	8	4	4
No Change	(10)	10	0	10
Total		48	24	24
Mean Maximum Color Response			4.7 ±2.5 (Moderate Change)	8.0 ±2.3 (Slight Change)
$t = 4.7302$ $P < .01$				

* Most marked color change among all digits of a given patient irrespective of degree of injury.
** Control determinations on same patients on different days.
*** Block performed on same extremity as that showing maximum change during control observation.

just before the patient entered the cold room. This phenomenon of differences in oral temperatures was to be expected since there was an interference with the normal temperature regulating apparatus which caused a loss of the heat-conserving vasoconstrictive ability of the blocked lower extremity.

It is apparent from these results that the sympathetic nervous system is, in some way, involved in the local pathophysiological response to cold that is exhibited by a previously frostbitten digit. The exact relationship remains obscure.

TABLE 7

COMPARISON OF ORAL TEMPERATURES DURING COLD STRESS WITH AND WITHOUT A LUMBAR SYMPATHETIC BLOCK

Patient Number	Temperature Change Control	Temperature Change Block
0002	+0.4° F.*	-0.3° F.*
0017	-0.2° F.	-0.9° F.
0021	+0.7° F.	-0.9° F.
0034	+0.1° F.	0.0
0045	-0.6° F.	-1.1° F.
0049	0.0	-0.1° F.
0050	-0.5° F.	-0.6° F.
0052	-0.6° F.	-0.5° F.
0053	-0.1° F.	-0.5° F.
0067	+0.2° F.	-1.0° F.
0079	-0.8° F.	-2.6° F.
0[illegible]2	-0.4° F.	-2.3° F.
0092	+0.1° F.	+0.8° F.
Mean	-0.13° F. ±0.42° F.	-0.77° F. ±0.87° F.
$t = 2.3865$ $P < .05$		

* Values with (+) sign refer to rises in oral temperature; those with (-) sign refer to drops in oral temperature.

Several possible explanations present themselves for consideration:

1) Local cooling is known to produce vasoconstriction by the direct action of cold upon the smaller blood vessels. It is possible that as a sequela of cold injury the threshold to the cold stimulus of the vessels in the region affected is lowered. This local hypersensitivity by the arterioles, capillaries and/or venules could cause the abnormal reaction seen when the previously frostbitten extremity is cooled. Sympathetic denervation of the limb, by increasing the blood flow through the involved part and consequently maintaining the

temperature of the blood vessels, would prevent the cold stimulus from becoming effective.

2) Another possibility is that the vessels injured by frostbite are hypersensitive not to cold but to impulses from the sympathetic nervous system regardless of their exciting stimulus. This would explain, in addition to the reaction induced by cold, the abnormal color changes in the digits which accompany strong emotion or dependency.

D. Hexamethonium

Hexamethonium was studied in three different ways in an attempt to evaluate its ability to change the skin color response of digits to cold in the post-frostbite patient. These three studies will be considered separately.

1. Hexamethonium Prior to Cold Exposure

Thirty-two determinations were performed on 29 patients of whom 14 were non-pigmented and 15 pigmented. Five were hand cases and 24 were foot cases. All but three of these received 50 mgm. of the drug intravenously within 5 minutes before entering the test chamber. In these three instances, 75 mgm. were used on a subsequent occasion after 50 mgm. failed to produce the expected response. Of the 29 patients, four showed no color deviation on control procedures, so could not be expected to benefit with respect to color changes by the drug. In Table 8 is demonstrated the highly significant

difference between the color change these 25 patients showed when hexamethonium was given prior to the cold exposure and the color change the same patients exhibited during a control determination.

TABLE 8

COMPARISON OF HEXAMETHONIUM (PRE-EXPOSURE*) WITH CONTROL DETERMINATIONS IN REGARD TO COLOR RESPONSE TO COLD STRESS

Maximum Color Response**		Total Patient Tests	Control***	Prophylactic Hexamethonium*
Marked Change	(during 1st half hour(1))	0	0	0
	(during 2nd half hour(2))	7	6	1
	(during 3rd half hour(3))	5	5	0
Moderate Change	(during 1st half hour(4))	2	2	0
	(during 2nd half hour(5))	2	2	0
	(during 3rd half hour(6))	5	3	2
Slight Change	(during 1st half hour(7))	1	1	0
	(during 2nd half hour(8))	5	4	1
	(during 3rd half hour(9))	2	2	0
No Change	(10)	21	0	21
Total		50	25	25
Mean Maximum Color Response			4.8 ±2.4 (Moderate Change)	9.3 ±1.9 (Slight Change)
t = 7.2/50 P <.01				

* Refers to therapy given intravenously within 5 minutes before entering cold room.

** Maximum color response refers to the most marked color change among all digits of a given patient irrespective of degree of injury.

*** Control determinations on same patients as those treated.

Referring to Table 9, it is noted that in comparison to control determinations on the same patients, there was a greater loss of body heat during exposure to cold after treatment with hexamethonium. This phenomenon was certainly to be expected when the normal temperature regulating apparatus was seriously handicapped by the

loss of its heat-conserving vasoconstrictive ability during a period of exposure to low ambient temperature. The effect was more pronounced than that observed with lumbar block, probably because the latter represented a much more localized vasodilatation.

TABLE 9

COMPARISON OF HEXAMETHONIUM (PRE-EXPOSURE*) WITH CONTROL DETERMINATIONS IN REGARD TO CHANGE IN ORAL TEMPERATURE DURING COLD STRESS

Patient Number	Temperature Change Control	Temperature Change Hexamethonium
0005	-0.2° F.**	-1.4° F.**
0017	-0.2° F.	-3.1° F.
0019	-0.2° F.	-2.4° F.
0025	0.0	-1.0° F.
0027	+0.1° F.	-1.5° F.
0037	-0.9° F.	-1.6° F.
0043	+0.4° F.	-1.4° F.
0052	-0.6° F.	-1.7° F.
0054	-0.2° F.	-0.8° F.
0056	+0.2° F.	-1.8° F.
0061	+0.6° F.	-0.9° F.
0062	-0.2° F.	-1.2° F.
0068	-0.9° F.	-2.0° F.
0069	+0.5° F.	-1.6° F.
0073	-0.2° F.	-1.6° F.
0081	+0.2° F.	-2.2° F.
0087	+0.2° F.	-1.3° F.
Mean	-0.09° F. ±0.42° F.	-1.64° F. ±0.61° F.
t = 8.6254 P <.01		

* Refers to therapy given within 5 minutes before entering cold room.

** Values with (+) sign refers to rises in oral temperature; those with (-) sign refer to drops in oral temperature.

2. Hexamethonium During Cold Exposure

Eighteen determinations were performed on 16 patients of whom 11 were non-pigmented and five were pigmented. Three were hand cases and 13 were foot cases. All but two of these were given 50 mgm. of hexamethonium

intravenously between a half hour and one hour after they entered the cold room. The remaining two were given 75 mgm. on a subsequent determination after failing to respond adequately to 50 mgm. An attempt was made to evaluate the improvement in the skin color as a result of the therapy. In Table 10 the maximum color deviation attained prior to therapy is compared with the minimum (or most nearly normal) color deviation after therapy but while the patient was still in the cold room. In some instances it was suspected that the patient was removed from the room prior to complete disappearance of the color response. In rare instances the color improved after therapy, giving the recorded minimum color deviation and then progressively becoming worse again before the patient left the cold room. Only three patients showed no improvement, three patients showed definite but incomplete disappearance of the abnormal skin color and 10 showed complete restoration of normal color.

The change in oral temperature (Table 11) resulting from the administration of hexamethonium was significantly different from that obtained in the same patients on control determinations. The difference was not as striking as before, because there was a shorter period of exposure to cold subsequent to vasodilatation.

TABLE 10

ALTERATION OF COLOR RESPONSE TO COLD STRESS FOLLOWING ADMINISTRATION OF HEXAMETHONIUM*

Patient Number	Skin Color Before Treatment	Skin Color After Treatment
0005	Moderate (3)**	None (1)**
0019	Slight (2)	None (1)
0023	Marked (4)	Marked (4)
0027	Marked (4)	Moderate (3)
0032	Slight (2)	None (1)
0033	Marked (4)	Marked (4)
0037	Marked (4)	None (1)
0041	Moderate (3)	None (1)
0043	Moderate (3)	None (1)
0044	Marked ([illegible])	Moderate (3)
0046	Marked (4)	Marked (4)
0049	Slight (2)	None (1)
0053	Marked (4)	None (1)
0059	Slight (2)	None (1)
0078	Slight (2)	None (1)
0081	Moderate (3)	Slight (2)
Mean	3.1 ±0.9 (Moderate)	1.9 ±1.3 (Slight)
t = 3.1469 P <.01		

* Hexamethonium given I.V. between 1/2 hour and 1 hour after entering cold room and after color change had developed.

** Color response was graded: 1 = none, 2 = slight, 3 = moderate, and 4 = marked color change in order to obtain mean.

3. Long Term Use of Hexamethonium

Eleven patients (five non-pigmented and six pigmented; four hand cases and seven foot cases) were given a 25 day course of hexamethonium, 50 mgm. intramuscularly every 6 hours. They were followed during the course of therapy by repeated exposures to cold as prescribed in the standard test procedure. All 11 patients were exposed to cold just before

initiation of therapy and at the end of one week of therapy. Two patients were observed during the second week and one during the third week of therapy. Ten patients were observed during the fourth week of therapy, and six cases were observed one week after the cessation of therapy.

TABLE 11

COMPARISON OF HEXAMETHONIUM (EXPOSURE*) WITH CONTROL DETERMINATIONS IN REGARD TO CHANGE IN ORAL TEMPERATURE DURING COLD STRESS

Patient Number	Temperature Change Control	Temperature Change Hexamethonium
[illegible]	-0.[illegible]° F.**	-0.[illegible]° F.**
0023	-0.3° F.	-2.5° F.
0027	+0.1° F.	-2.0° F.
0032	-0.5° F.	-1.7° F.
0033	0.0	-1.2° F.
0037	-0.[illegible]° F.	-3.[illegible]° F.
00[illegible]3	+0.[illegible]° F.	-0.7° F.
00[illegible]4	-[illegible]° F.	-0.3° F.
00[illegible]6	+0.5° F.	-1.6° F.
00[illegible]	0.0	-1.7° F.
0053	-0.1° F.	-3.9° F.
00[illegible]9	+0.5° F.	-0.[illegible]° F.
00[illegible]	-0.2° F.	-0.6° F.
00[illegible]1	+0.2° F.	-1.5° F.
Mean	-0.05° F. ±1.16° F.	-1.57° F. ±1.04° F.
t = 3.7101 P <.01		

* Refers to therapy given I.V. between 30 min. and 60 min. after patient entered cold room.

** Values with (+) sign refer to rises in oral temperature; those with (-) sign refer to drops in oral temperature.

The results of this study are tabulated in Table 12. Statistical evaluation, comparing the observations during the first week of therapy with those prior to initiation of therapy, revealed a significant improvement as a result of therapy. During the latter

weeks of therapy the improvement was also significant, but in the cases observed after cessation of therapy, there was no significant difference from the pretest control.

TABLE 12

COMPARISON OF MAXIMUM COLOR RESPONSE TO COLD STRESS BEFORE, DURING AND AFTER TWENTY-FIVE DAY COURSE OF HEXAMETHONIUM*

Patient Number	Maximum Color Response to Cold Stress			
	Before Therapy	During 1st Week	During 4th Week	After Therapy
[illegible]	5+	6+	5+	5+
0033	3	2	3	3
[illegible]	3	6	8	6
0050	9	6	6++	-
0053	3	10	8	7
[illegible]	5	8	-	-
[illegible]	3	3	2	-
[illegible]	4	8	7	7
[illegible]	2	8	6	8
[illegible]	3	3	9	-
0109	3	7	10	-
Total Patients Tested	11	11	10	6
Mean Color Response	3.7 ±2.0 (Moderate)	6.1 ±2.6 (Delayed Moderate)	6.2 ±2.9 (Delayed Moderate)	5.7 ±2.4 (Slightly delayed Moderate)
t+++	-	[illegible]+++	[illegible]+++	1.[illegible]+++
P		<0.05	<0.05	>0.1

* Dosage 50 mgm. intramuscularly every 6 hours.

\+ Responses graded 1 through 10 from maximum to minimum as described in text and used in Tables 4, 6 and 11.

++ Observation made during third week instead of fourth.

+++ t value expressed in each column is a comparison between the mean in that column and the mean in the pre-treatment control column.

Side effects due to the drug consisted of frequent complaints of constipation requiring laxatives, of transient blurred vision after administration of each dose, of transient postural hypotension with associated

dizziness for a short period of time after each dose, and the rare complaint of urinary retention which was relieved without catheterization. There was an apparent gradual adaptation to the hypotensive effect of hexamethonium, so that during the last 2 weeks of therapy most of the patients were able to resume the normal activity of an ambulatory convalescent hospital patient immediately after receiving their injections, whereas they had been forced to remain supine for approximately 2 hours after each injection during the earlier days of therapy.

The results of those studies with hexamethonium suggested promise in the ability to alter the response of the vascular bed of a post-frostbite digit exposed to cold. It would seem that this type of therapy might prove valuable in increasing the oxygenation of frostbitten tissues during healing when there is an associated vasospastic phenomena of the involved extremity such as coldness, pallor and/or cyanosis. These phenomena were commonly seen during the time that a third degree ulceration was healing and usually influenced the rate of healing of the lesion. Lempke,* in a small series of cases, showed that small full thickness skin grafts applied to these third degree ulcerations were more frequently viable when the patient was simultaneously treated with hexamethonium than when he was not. This finding lends support

* See Section XII, Part II of this report.

to the hypothesis that hexamethonium improves the blood flow to the ulcer bed.

E. Priscoline

Priscoline was studied by the same three methods as described above for hexamethonium. The results obtained are recorded below.

1. Priscoline Prior to Cold Exposure

Twenty-three determinations were performed on 23 patients of whom 15 were non-pigmented and eight pigmented. Four were hand cases and 19 were foot cases. All except two patients received 50 mgm. of the drug intravenously within 5 minutes before entering the cold room. The remaining two received 75 mgm., having failed to show what was considered to be a satisfactory response previously (these two former observations were made prior to 15 January 1952 and were discarded). Other cases which failed to respond to 50 mgm. of the drug intravenously were not similarly subjected to increased dosage.

Four of the 23 cases showed no color response on their control determinations, so could not be expected to show variation in color due to the drug. Results obtained on the remaining 19 cases are shown in Table 13. Of the 19, five showed no improvement with priscoline, 10 showed definite improvement, and four were completely prevented from developing the color change which they had shown

on the control determination. There was no significant difference between this group and its controls when oral temperature change was evaluated as it was for hexamethonium in Table 9.

TABLE 13

COMPARISON OF PRISCOLINE (PRE-EXPOSURE*) WITH CONTROL DETERMINATIONS IN REGARD TO COLOR RESPONSE TO COLD STRESS

Maximum Color Response**		Total Patient Tests	Control***	Prophylactic* Priscoline
Marked Change	(during 1st half hour (1))	0	0	0
	(during 2nd half hour (2))	8	5	3
	(during 3rd half hour (3))	11	9	2
Moderate Change	(during 1st half hour (4))	1	1	0
	(during 2nd half hour (5))	2	1	1
	(during 3rd half hour (6))	6	2	4
Slight Change	(during 1st half hour (7))	0	0	0
	(during 2nd half hour (8))	4	1	3
	(during 3rd half hour (9))	2	0	2
No Change	(10)	4	0	4
Total		[illegible]	19	19
Mean Maximum Color Response			4.0 ±2.1 (Moderate Change)	6.2 ±2.9 (Delayed Moderate Change)

$t = 2.9171$
$P < 0.01$

* Refers to therapy given intravenously within 5 minutes before entering cold room.
** Maximum Color Response refers to the most marked color change among all digits of a given patient irrespective of degree of injury.
*** Control determinations on same patient as those treated.

2. Priscoline During Cold Exposure

Twelve determinations were performed on 12 patients of whom seven were non-pigmented and five were pigmented. One was a hand case and the remainder were foot cases. All received 50 mgm. of priscoline intravenously between a half hour and one hour after they entered the cold room. Four of these patients had

developed no color change prior to the time the drug was administered. The remaining eight cases represented a small series for evaluation, but in comparing the color prior to administration of the drug with that which was present at the time of its maximum improvement while still in the test chamber, it was noted that only one patient was completely relieved of the abnormal color, four were improved, and three showed no improvement. When tabulated and analyzed in the same way that hexamethonium was evaluated (Table 10), this improvement was not significant for the small number of cases.

3. Long Term Use of Priscoline

Eleven patients (eight non-pigmented and three pigmented; two hand cases and nine foot cases) were given a 25 day course of priscoline 50 mgm. orally four times a day. They were followed during the course of therapy by repeated exposures to the standard test procedure. All 11 patients were submitted to the procedure just before onset of therapy. Nine were observed during the first week and the remaining two during the second week of therapy. Ten were observed during the fourth week, and seven were exposed to cold stress one week after cessation of therapy. When compared with their control observations, (as hexamethonium was in Table 12), these patients showed no significant improvement during the course of therapy. It is recognized by the authors that

this does not constitute adequate trial of the drug, since the intramuscular route of administration has not been explored. The dosages administered may have been too small or too widely spaced in time of administration.

IV. SUMMARY AND CONCLUSIONS

A procedure for exposing the hands and/or feet of a human subject to a reproducible cold stress has been described. This procedure, using cold stress, was of value in elucidating the phenomena of abnormal vasomotor lability in previously frostbitten extremities.

Seventy-two patients, all young adult male soldiers having recently recovered from first, second and/or third degree frostbite were submitted to a standard cold stress procedure for a total of 361 times during a 3 month period of time. Distribution of cases according to site, degree of injury and race was recorded.

Three hundred twenty-five of the determinations were analyzed, including 149 intermittent control observations which were evaluated with regard to the number of weeks post-frostbite at which the observation was made and the severity of injury of the digit involved. These control observations were compared with observations on the same patients during treatment with lumbar sympathetic block, hexamethonium and priscoline.

The results demonstrated the following:

1) A significant relationship between degree of injury and severity of color response of digits to cold stress.

2) A significant alteration of the color response with lumbar sympathetic block, hexamethonium and to a lesser degree priscoline.

3) A significant relationship between the site of pain on exposure to cold and the site of marked color change.

4) A significant relationship between the site of pain and the severity of frostbite previously sustained.

5) A significant lowering during the periods of cold stress of oral temperatures of those patients treated either with hexamethonium or sympathetic blocks, but not with priscoline.

ARMY MEDICAL RESEARCH LABORATORY

FORT KNOX, KENTUCKY

REPORT NO. 113
1 April 1953

COLD INJURY - KOREA 1951-52*

Section XI
COLD STRESS STUDIES ON POST-FROSTBITE PATIENTS
Part II - Skin Temperature Changes

*Subtask under Environmental Physiology, AMRL Project No. 6-64-12-028, Subtask (8K), Cold Injury Studies.

MEDICAL RESEARCH AND DEVELOPMENT BOARD
OFFICE OF THE SURGEON GENERAL
DEPARTMENT OF THE ARMY

SECTION XI

COLD STRESS STUDIES ON POST-FROSTBITE PATIENTS

PART II: Skin Temperature Studies

by

Robert E. Lempke
1st Lt. MC, AUS

TABLE OF CONTENTS

COLD STRESS STUDIES ON POST-FROSTBITE PATIENTS

PART II: Skin Temperature Studies

I. INTRODUCTION

The clinical course of frostbitten extremities has been described in detail elsewhere (1). Immediately after injury the involved digits are usually warm, relatively hypohidrotic and hypesthetic. In the case of first and the milder second degree injuries these findings appear to be part of the sterile inflammatory reaction resulting directly from the cold insult. Their duration is directly related to the severity of the original injury, 1 to 3 weeks for first degree and 2 to 7 weeks for second degree lesions. Digits which have sustained a more severe injury may exhibit local increased warmth, anhidrosis and anesthesia for as long as 3 months after frostbite. In the absence of cellulitis this suggests that cutaneous denervation has occurred. In each instance this initial phase is usually followed by the appearance of abnormal vasomotor lability. This is the post-frostbite sequela of importance, secondary only to extensive tissue loss, in determining the subsequent disability experienced by patients with this injury. It is characterized by the clinical manifestations of increased sympathetic nervous system activity, namely inability to keep the affected part warm, pallor or cyanosis, and increased sweating.

The excessive perspiration which accompanies this post-cold injury syndrome did not constitute a serious problem in the frostbite patients studied, at least in the convalescent hospital environment in which they were observed. However, the vasoconstrictive component of the syndrome with its resultant decrease in blood flow through the affected

part was of significance. The ulceration of toes with third degree frostbite, if not healed before the onset of this phase re-epithelialized slowly and skin grafts would not survive on the poorly vascularized ulcer bed (Section VI). Later manifestations of this derangement of the circulation as observed under standard conditions of cold stress have been reported in Part I of this section.

During the performance of these cold stress tests, skin temperature measurements were made in order to obtain an objective measure of the circulatory status of patients who had recently been frostbitten. These temperature data are the subject of this report.

II. METHODS

The cold stress test was applied in the manner described in Part I to 72 subjects who recently had recovered from the acute effects of frostbite. During the initial equilibration period as well as the 3-hour period of observation following the cold exposure the subjects were in a large, high-ceilinged room with an ambient air temperature which averaged 22.3° C. (72.2° F.), standard deviation of ± 1.4° C., and a relative humidity of 32.3% with a standard deviation of ± 8.7%. These measurements were made with a continuously recording hygrometer and thermograph. The cold exposure itself took place in a walk-in refrigerator 24 by 10 by 10 feet in size with an average ambient temperature of 10.3° C. (50.5° F.), standard deviation ± 0.4° C., and with an average relative humidity of 60.5%, standard deviation ± 4.0%. These conditions, with the exception of the temperature within the refrigerator, were obligatory. Although they were reasonably constant during any one test the levels of the temperature and relative humidity were subject to only limited control. In the interest of obtaining

more reliable cooling and rewarming curves an ambient air temperature of approximately 85° F. (29.4° C.) outside of the refrigerator would have been preferred in order to ensure full vasodilatation both before and after cooling. Air movement was not uniform throughout the refrigerator and could not be eliminated since two fans were an integral part of the cooling mechanism. The relative position of the five patients being tested at any one time, however, was randomized during successive tests.

Skin temperature determinations were made during the latter half of the pre-exposure equilibration period, throughout the cold exposure and for 3 hours after exposure at intervals of approximately 12 minutes. It was impractical to make continuous recordings. The temperatures were measured by means of a manually applied copper-constantan thermocouple junction mounted at a distance of 2.5 cm. from a nonconducting handle and connected to a recording potentiometer. Sufficient time was allowed to elapse after each application to ensure the attainment of thermal equilibrium between the junction and the skin. The potentiometer was calibrated periodically and over the temperature range employed gave readings which deviated from the true temperature by a maximum of + 0.6° C. The recorded temperatures were read to the nearest 0.25° C. which was found to be the range of reproducibility of repeated determinations of the temperature of any given point under stable conditions.

Measurements were taken from multiple points on the feet (Figure 1) of all subjects tested, but the analysis presented here was confined to the temperature data collected from the great toes and the anterior aspect of the ankles of 27 patients during 55 tests. These were all the subjects who had sustained a cold injury of the feet with the great

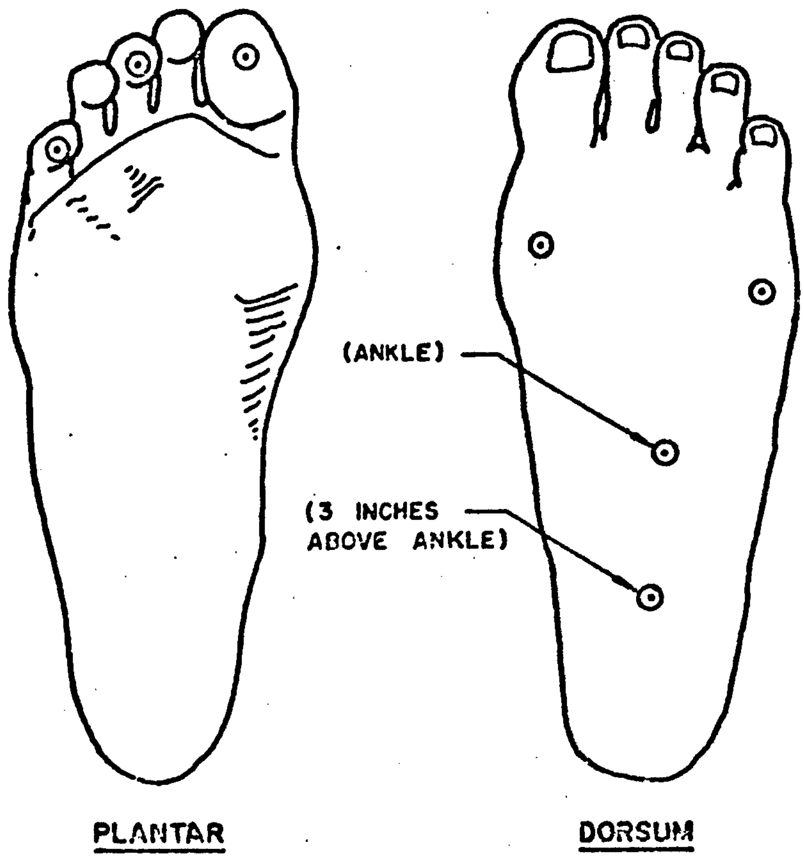


FIGURE 1. LOCATIONS OF SKIN TEMPERATURE POINTS ON THE LOWER EXTREMITIES.

toes dissimilarly involved and on whom the hands had been spared. This selection was made to permit comparisons between the responses of toes with different degrees of frostbite while minimizing the variations which exist between individuals. The great toe was selected because it was the digit most frequently and most severely injured. The skin over the anterior aspect of the ankles midway between the malleoli was chosen as an uninjured reference point.

The tests analyzed were restricted further to those which were not complicated by any medication or procedure designed to alter the response to cold.

The subjects were divided, for the purpose of analysis, into five groups according to the severity of frostbite of the two great toes. They were: 1) "uninjured" and second degree, 2) "uninjured" and third degree, 3) first and second degree, 4) first and third degree and 5) second and third degree. No cases of "uninjured" and first degree were available for study. The term "uninjured" was employed in cases of unilateral frostbite to designate the great toe which had not sustained a cold injury as determined by history and physical examination. Since these digits presumably were exposed to the same cold stress which had produced frostbite of the opposite foot, they may not have escaped injury completely.

Two measures of cooling were analyzed: 1) the difference between the temperature of the toe and that of the ambient air after equilibration at a temperature of 22° C. for one hour before cold exposure and 2) the rate of cooling of the great toe relative to that of the ankle in an environmental temperature of 10° C. The latter measure was the algebraic difference between the cooling rates of the skin of the great

toes and the corresponding ankles calculated as an exponential function of temperature change with time in accordance with Newton's law of cooling.

In addition to the environmental factors which could not be controlled with the exactitude desired, the skin temperature measurements were influenced by certain anatomical and physiological variables which were not assessed. Some of these factors may have had a significant effect upon the results. For example, the skin at the site of a previous second or third degree lesion was usually thin and smooth, especially in the case of the latter degree which also was frequently anhidrotic and the site of some subcutaneous tissue loss. These factors may have produced a higher skin temperature than would have been obtained under the same conditions in their absence. Their influence probably would be greater on the toe-ambient air temperature difference at equilibrium before exposure than on the cooling rate during cold exposure, since the former is a measure of the extent of cooling and the latter is concerned with the rate of change in temperature. The equilibrium temperature measurement, furthermore, did not take into consideration the variations between individuals and between successive tests on the same individual due to such factors as difference in metabolic rate and general vasomotor tone which may have influenced the cooling of a digit but are not necessarily related to the injury of the toe under study.

In the study of cooling at 10° C. an attempt was made to minimize the influence of these latter variables by using the difference between the cooling rates of the toe and ankle in the analysis. Since the skin of the ankle of each patient was uninjured its cooling rate was

considered as a measure of the general vasomotor status of the individual. This basal cooling rate of the extremity would reflect any changes in these variable internal factors and, hence, subtracting the cooling rate of the ankle from that of the toe would tend to isolate the effect of the frostbite lesion of the digit upon its response to cold. Although this value was expressed precisely in units of "degrees Centigrade per minute per degree Centigrade" it was not considered to have any real thermodynamic significance. It was used merely as a value, quantitatively derived, which expressed the relative effect of various degrees of frostbite upon the cooling rate of the digits involved.

Three control subjects who had never had a cold injury were also tested. In addition to the exposure at an ambient air temperature of 50° F. they were studied at 35°, 40° and 60° F.

III. RESULTS

A. Toe-Ambient Temperature Gradients

The temperature of the room during the equilibration period before exposure was sufficiently low (22° C.) to produce vasoconstriction in most of the subjects as evidenced by pallor or even slight cyanosis of the toes. The mean toe-ambient temperature gradients (the difference between the temperature of the toe and the ambient air after equilibration) of the patients grouped according to the combination of injuries of their great toes are recorded in Table 1. Comparisons between these values by degree of injury within each combination of lesions showed no statistically significant differences. The toe with the lesser degree of frostbite cooled to a lower

temperature (i.e. had a smaller toe-ambient temperature gradient) on the average than the opposite toe with a more severe lesion, except in those subjects with a third degree injury of one toe, in which case the mean gradients were approximately equal bilaterally. The mean gradients were higher in subjects with a third degree lesion than in those with less severe injuries.

TABLE 1

MEAN TOE-AMBIENT TEMPERATURE GRADIENTS AFTER EQUILIBRATION OF THE GREAT TOES OF PREVIOUSLY FROSTBITTEN SUBJECTS.

Degree of Injury*	Number of Tests	Mean Toe-Ambient Temperature Gradient °C.	S.D.	t	P
0 2	13	1.5 2.5	± 2.25 ± 2.06	1.129	>.20
0 3	7	4.6 4.3	± 1.88 ± 2.01	0.375	>.70
1 2	13	1.9 2.9	± 3.09 ± 3.01	0.800	>.40
1 3	12	4.2 4.7	± 2.98 ± 2.06	0.438	>.60
2 3	10	4.2 5.3	± 2.05 ± 2.31	1.071	>.20

* In this and subsequent tables "0" designates the uninjured great toe of patients who had sustained frostbite of the opposite great toe.

Comparisons between the mean gradients of toes with like degree of injury but with lesions of dissimilar severity of the contralateral toe and conversely between the mean gradients of toes with frostbite of unlike degree but with lesions of similar severity of the opposite toe (Table 2) revealed some significant differences. For example, uninjured toes in patients who had a third degree lesion of the opposite toe

TABLE 2

COMPARISONS OF THE MEAN TOE-AMBIENT TEMPERATURE GRADIENTS DEMONSTRATING THE EFFECT OF DIFFERENT DEGREES OF FROSTBITE OF ONE GREAT TOE UPON THE RESPONSES OF THE CONTRALATERAL TOE.

Degree of Injury*	Number of Tests	Mean Toe-Ambient Temperature Gradient °C.	S.D.	t	P
0 (2)	13	1.5	± 2.25	3.295	<.01
0 (3)	7	4.6	± 1.88		
1 (2)	13	1.9	± 3.09	1.893	>.05
1 (3)	12	4.2	± 2.98		
2 (0)	13	2.5	± 2.06	0.416, 1.255 } 2.035	>.60, >.20 } >.05
2 (1)	13	2.9	± 3.01		
2 (3)	10	4.2	± 2.05		
3 (0)	7	4.3	± 2.01	0.458, 0.628 } 0.981	>.60, >.50 } >.30
3 (1)	12	4.7	± 2.06		
3 (2)	10	5.3	± 2.31		
2 (0)	13	2.5	± 2.06	1.863	>.05
3 (0)	7	4.3	± 2.01		
2 (1)	13	2.9	3.01	1.755	>.05
3 (1)	12	4.7	- 2.06		
0 (2)	13	1.5	± 2.25	0.396, 2.956 } 3.917	>.60, <.01 } <.001
1 (2)	13	1.9	± 3.09		
3 (2)	10	5.3	± 2.31		
0 (3)	7	4.6	± 1.88	0.366, -- } 0.427	>.70, — } >.60
1 (3)	12	4.2	± 2.98		
2 (3)	10	4.2	± 2.05		

* The number in parentheses after the degree of injury denotes the degree of injury of the contralateral great toe.

did not cool to as low a temperature as did similar uninjured toes in patients with second degree frostbite of the corresponding contralateral digit. In like manner, great toes which had sustained a third degree injury had significantly higher gradients, on the average, than toes which had first degree lesions when the contralateral toe in both instances had second degree frostbite. In general, the toes with a third degree lesion and toes with less severe injuries but whose contralateral counterpart had sustained a third degree injury cooled the least in a mildly cool environment.

For this reason the results cannot be combined by degree of injury irrespective of the lesion of the opposite toe when the latter is third degree. Therefore, the combined mean gradients for each degree of frostbite shown in Table 3 do not include the values obtained from toes with no injury or with first degree frostbite when present in the same patient with a third degree injury of the opposite foot. Toes with second degree frostbite were not influenced significantly by a third degree lesion of the contralateral toe and hence were not omitted from the calculations. Included in this table are the results obtained from the three control subjects.

The results of statistical comparisons between these mean gradients of the toes combined without regard to the lesion on the contralateral toe and of the control digits are summarized in Table 4. The toes with third degree frostbite had a significantly higher mean gradient than did any of the digits with lesser injuries or with no injury. The toes of the

TABLE 3

THE MEAN TOE-AMBIENT TEMPERATURE GRADIENTS OF THE GREAT TOES COMBINED BY DEGREE OF INJURY IRRESPECTIVE OF THE INJURY OF THE OPPOSITE TOE

Degree of Injury	Number of Tests	Mean Toe-Ambient Temperature Gradient °C.	S.D.
Control	22	3.0	± 3.15
0*	13	1.5	± 2.25
1*	13	1.9	± 3.09
2	26	2.7	± 2.49
3	29	4.8	± 2.03

* Values for toes with third degree frostbite of the opposite great toe excluded.

TABLE 4

COMPARISONS BETWEEN THE MEAN TOE-AMBIENT TEMPERATURE GRADIENTS AFTER EQUILIBRATION OF THE GREAT TOES OF PREVIOUSLY FROSTBITTEN AND CONTROL SUBJECTS (TABLE 3)

Degree of Injury of Toes Compared	t	P
Control vs 0	1.598	>.10
" vs 1	0.963	>.30
" vs 2	0.361	>.70
" vs 3	2.325	<.05
0 vs 1	0.396	>.60
0 vs 2	1.481	>.10
0 vs 3	4.466	<.001
1 vs 2	0.758	>.40
1 vs 3	3.021	<.01
2 vs 3	3.371	<.01

control subjects and the toes with second degree frostbite cooled to essentially the same extent, which was somewhat less than that to which toes with no injury or first degree frost-

bite cooled although the difference was not significant statistically.

B. Cooling Rates

During the cold exposure the great toes of the patients and the control subjects cooled at varying rates but with few exceptions (the toes of patients with third degree frostbite in particular) had ceased to cool in less than 50 minutes. After that time the skin temperature of the toes either stabilized close to that of the ambient air (either at, above or below it) or exhibited the cyclic fluctuations described as the "hunting" phenomenon. Cooling of the toes to temperatures below that of the environment was attributed to the evaporation of perspiration.

The mean "corrected cooling rates" (the algebraic difference between the cooling rates of the ankle and toe) of the great toes of the control subjects at ambient air temperatures of 35°, 40°, 50° and 60° F. are recorded in Table 5. The statistical comparisons between these values summarized in Table 6 show that the mean cooling tendency did not vary significantly at 40°, 50° and 60° F. and in each instance was greater than at 35° F. Only the difference between the mean cooling rates at 50° and 35° F. was statistically significant. The similarity in the mean cooling rates of the toes at the three higher ambient temperatures may be misleading. A longitudinal survey of the results showed that in only one instance was the cooling rate greater at 60° F. than at 50° F. In three of the six toes tested cooling was less rapid at 40°

than at 50° F. but these toes were those which cooled slowest at 35° F. In every case the toes cooled more slowly at 35° than at 40° F. Therefore, a larger number of observations might have yielded a higher mean cooling rate at 50° than at 60° F. The lack of a significant difference between the cooling at 50° and 40° F. may be due to individual variation in the temperature at which cooling ceased to increase with lowering of the ambient temperature.

TABLE 5

MEAN CORRECTED COOLING RATES OF THE GREAT TOES OF CONTROL SUBJECTS AT VARIOUS AMBIENT AIR TEMPERATURES

Ambient Air Temperature °F.	Number of Tests	Mean Corrected Cooling Rate	
		°C./min./°C.	S.D.
35	6	.0136	± .0053
40	6	.0280	± .0152
50	6	.0247	± .0088
60	4	.0250	± .0146

TABLE 6

COMPARISONS BETWEEN THE MEAN CORRECTED COOLING RATES OF THE GREAT TOES OF CONTROL SUBJECTS AT VARIOUS AMBIENT AIR TEMPERATURES (TABLE 5)

Ambient Air Temperature of Tests Compared °F.	t	P
35 vs 40	2.195	>.05
35 vs 50	2.657	<.05
35 vs 60	1.500	>.10
40 vs 50	0.455	>.60
40 vs 60	0.316	>.70
50 vs 60	0.030	>.90

The cold stress testing of the frostbite patients was performed at an ambient temperature of 50° F. because it was found to be effective in eliciting the skin color changes and did not cause excessive discomfort to the subjects. The mean corrected cooling rates for each degree of injury in the five combinations of lesions studied are shown in Table 7 together with the results of "t" comparisons. No statistically significant differences existed but a tendency was noted for toes with either a second or third degree lesion to cool at a lower rate than the contralateral toe with a first degree injury.

TABLE 7

THE MEAN CORRECTED COOLING RATES OF THE GREAT TOES OF PATIENTS WITH FROSTBITE OF BILATERALLY ASYMMETRICAL SEVERITY

Degree of Injury	Number of Tests	Mean Corrected Cooling Rate		t	P
		°C./min./°C.	S.D.		
0 2	13	.0321 .0317	± .0206 ± .0165	0.055	>.90
0 3	7	.0361 .0312	± .0204 ± .0231	0.422	>.60
1 2	13	.0411 .0255	± .0263 ± .0277	1.472	>.10
1 3	12	.0331 .0173	± .0270 ± .0148	1.775	>.05
2 3	10	.0286 .0284	± .0274 ± .0322	0.016	>.90

The cooling curves presented in Figures 2 and 3 show that a third degree lesion did have some effect upon the cooling of an opposite toe, for example, one with first degree frostbite. The toes with a first degree lesion did not cool to

the same extent when the opposite toe had sustained third degree frostbite (Figure 2) as when the opposite toe was the site of second degree frostbite (Figure 3). In contrast to the mean toe-ambient temperature gradients (Table 2), the mean cooling rates of the great toe were not significantly influenced by the presence of a third degree lesion of the contralateral toe (Table 8). Therefore, the mean corrected cooling rate of the toes grouped by degree of injury irrespective of the severity of the lesion of the contralateral toe was utilized in the analysis. The values thus obtained together with that of the control subjects when exposed at 50° F. are reported in Table 9. A summary of the results of comparisons between the mean cooling rates of toes with each degree of frostbite and the control toes is presented in Table 10. None of the differences were statistically significant. The toes of the control subjects and those with second and third degree frostbite cooled on the average at almost the same rate. Similarly, digits with first degree lesions and the uninjured toes of patients with unilateral frostbite had approximately the same mean cooling rate which was greater than that of toes with the other three degrees of injury but not to the point of statistical significance.

The correlation between the corrected cooling rates of 90 toes which had had first, second or third degree frostbite and the degree of injury, using the method of Pearson yielded a correlation coefficient of -0.207. This value indicated a tendency for the toes with the more severe frostbite insult to

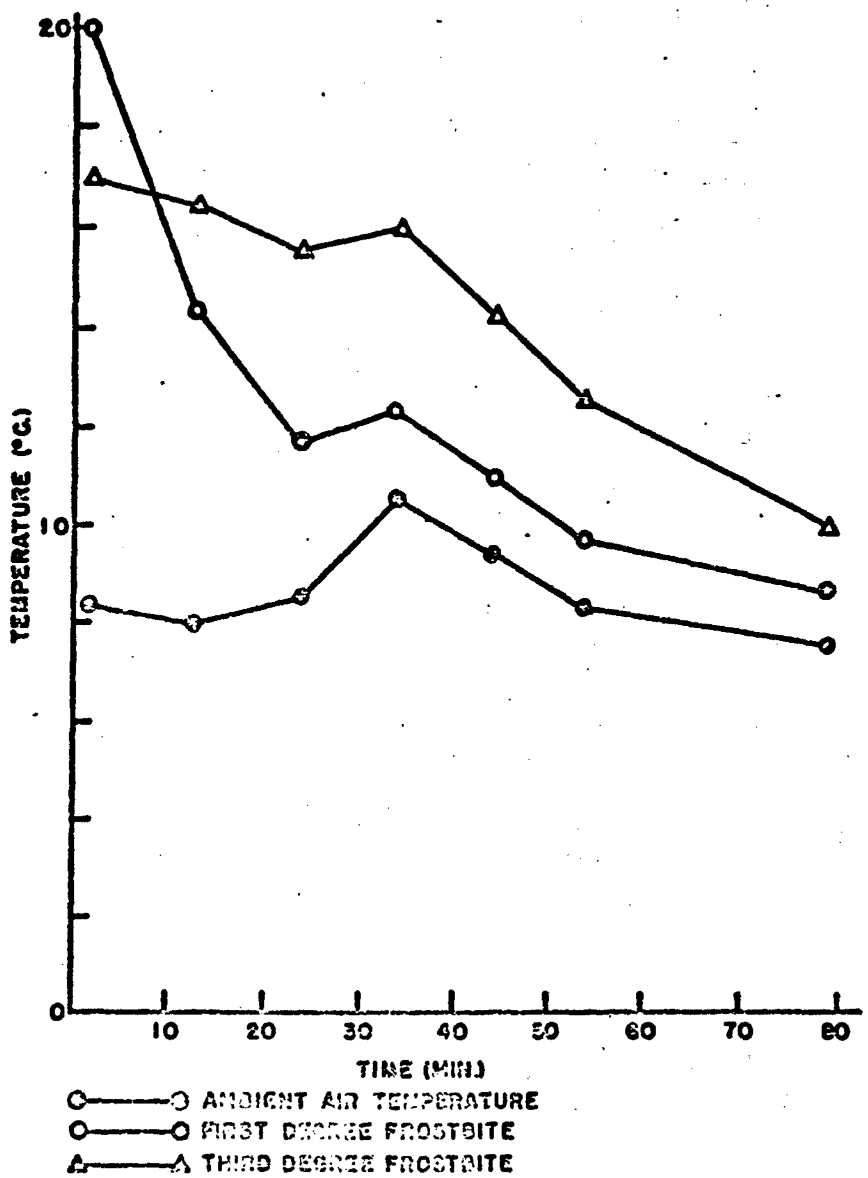


FIGURE 2. COOLING CURVES OF THE GREAT TOES OF A PATIENT WITH FIRST AND THIRD DEGREE FROSTBITE.

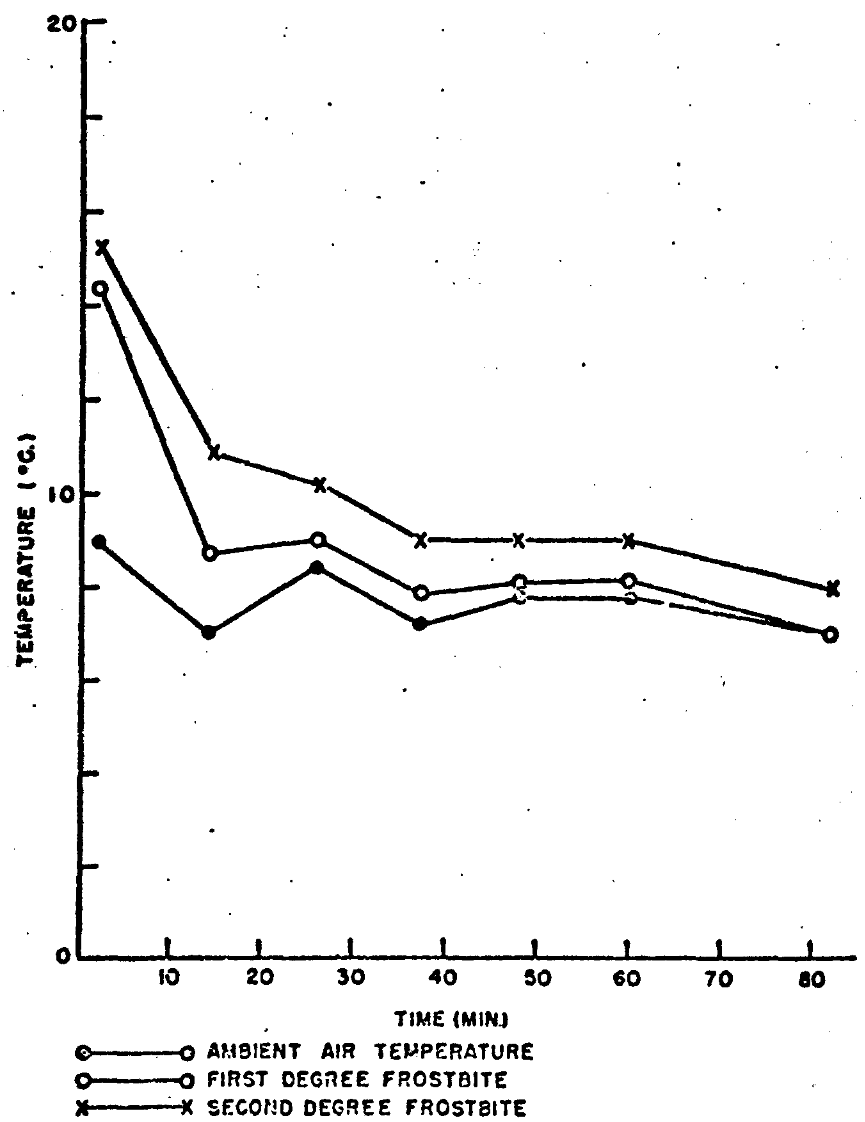


FIGURE 3. COOLING CURVES OF THE GREAT TOES OF A PATIENT WITH FIRST AND SECOND DEGREE FROSTBITE.

cool at a lower rate. However, the difference between the coefficient and zero was of only borderline significance and had no predictive value.

An analysis of the corrected cooling rates revealed that the response of previously frostbitten toes to cold tended to change with the passage of time. This is illustrated by the rank order correlation coefficients summarized in Table 11. The data from which these coefficients were calculated is presented in Appendix Tables 1 through 10.

TABLE 8

COMPARISONS BETWEEN THE MEAN CORRECTED COOLING RATES ILLUSTRATING THE INFLUENCE OF THE DEGREE OF INJURY OF ONE TOE UPON THE COOLING OF THE OPPOSITE GREAT TOE

Degree of Injury of Toes Compared*	Number of Tests	Mean Corrected Cooling Rate °C./min./°C.	S. D.	t	P
0 (2) 0 (3)	13 7	.0321 .0361	± .0206 ± .0204	0.417	>.60
1 (2) 1 (3)	13 12	.0411 .0331	± .0263 ± .0270	0.748	>.40
2 (0) 2 (1) 2 (3)	13 13 10	.0317 .0255 .0286	± .0165 ± .0277 ± .0274	0.697) 0.267) 0.316	>.40) >.70) >.70
3 (0) 3 (1) 3 (2)	7 12 10	.0312 .0173 .0284	± .0231 ± .0148 ± .0322	1.433) 1.121) 0.224	>.10) >.20) >.80
2 (0) 3 (0)	13 7	.0317 .0312	± .0165 ± .0231	0.051	>.90
2 (1) 3 (1)	13 12	.0255 .0173	± .0277 ± .0148	0.932	>.30
0 (2) 1 (2) 3 (2)	13 13 10	.0321 .0411 .0284	± .0206 ± 0263 ± .0322	0.968) 1.016) 0.316	>.30) >.30) >.70
0 (3) 1 (3) 2 (3)	7 12 10	.0361 .0331 .0286	± .0204 ± .0270 ± .0274	0.204) 0.385) 0.647	>.70) >.70) >.50

* The number in parentheses after the degree of injury denotes the degree of injury of the contralateral great toe.

TABLE 9

THE MEAN CORRECTED COOLING RATES OF THE GREAT TOES COMBINED BY DEGREES OF INJURY IRRESPECTIVE OF THE INJURY OF THE OPPOSITE TOE

Degree of Injury	Number of Tests	Mean Corrected Cooling Rate	
		°C./min./°C.	S. D.
Control	6	.0247	± .0088
0	20	.0335	± .0195
1	25	.0372	± .0259
2	36	.0286	± .0223
3	29	.0245	± .0231

TABLE 10

COMPARISONS BETWEEN THE MEAN CORRECTED COOLING RATES OF THE GREAT TOES OF PREVIOUSLY FROST-BITTEN AND CONTROL SUBJECTS (TABLE 9)

Degree of Injury of Toes Compared	t	P
Control vs 0	1.571	>.10
" vs 1	1.984	>.05
" vs 2	0.750	>.40
" vs 3	0.036	>.90
0 vs 1	0.544	>.50
0 vs 2	0.860	>.30
0 vs 3	1.475	>.10
1 vs 2	1.344	>.10
1 vs 3	1.896	>.05
2 vs 3	0.719	>.40

The time of the tests varied from 27 to 137 days after injury except in the case of patients with a unilateral third degree lesion in which the tests were performed from 15 to 88 days after frostbite. There was a positive correlation between the cooling rate and the time of the test after injury in the case of toes with third degree frostbite except in patients with a unilateral lesion. This discrepancy may have been due

to the above mentioned fact that no tests were performed on the latter group later than 88 days post-injury. Toes with second degree lesions in patients with first degree frostbite of the opposite great toe cooled more slowly as the time after injury increased. A similar tendency was exhibited by toes with second degree frostbite in patients with a unilateral injury. Uninjured toes and those with first degree frostbite tended to change with time in the same direction as the lesion of the contralateral toe, as did those with a second degree lesion where the opposite toe was the site of a third degree injury. In this respect the results confirm the effect of the lesion on one foot upon the response to cold of the opposite foot noted previously in the analysis of the toe-ambient temperature gradients.

TABLE 11

RANK ORDER CORRELATIONS BETWEEN THE CORRECTED COOLING RATES OF THE GREAT TOES OF PREVIOUSLY FROSTBITTEN SUBJECTS AND THE TIME OF TEST AFTER INJURY

Degree of Injury*	Number of Tests	Correlation Coefficient	P
0 (2)	13	- .015	>.05
0 (3)	7	+ .143	>.05
1 (2)	13	- .082	>.05
1 (3)	12	+ .371	>.05
2 (0)	13	- .205	>.05
2 (1)	13	- .698	<.01
2 (3)	10	+ .482	>.05
3 (0)	7	- .357	>.05
3 (1)	12	+ .587	<.05
3 (2)	10	+ .785	<.01

* The number in parentheses after the degree of injury denotes the degree of injury of the contralateral great toe.

A comparison of the mean corrected cooling rates for each degree of injury before and after 90 days post-frostbite, the dichotomy in respect to time which by trial and error was determined to show the greatest differences, furnished a measure of the changes which occurred with time (Table 12). The mean cooling rate of third degree lesions was greater after 90 days post-frostbite than before, and to a lesser extent the reverse tended to be true of toes with no injury and those with second degree lesions. The differences were not statistically significant, however. Digits with first degree frostbite remained essentially unchanged, the mean cooling rate being slightly higher after 90 days than before.

Comparisons between the mean cooling rates of the toes of control and frostbitten subjects within the two time periods are summarized in Table 13. In the earlier period third degree lesions cooled significantly slower than uninjured toes and exhibited a tendency in that direction in respect to the control digits and those with first and second degree lesions. After 90 days post-injury these toes cooled faster on the average than all others except those with first degree frostbite. Uninjured toes of frostbitten patients and those with first and second degree injuries tended to cool faster than the controls during the first 90 days after injury. Later the mean cooling rate of the uninjured and second degree frostbitten toes approached more closely that of the controls.

C. Rewarming

TABLE 12

COMPARISONS BY DEGREE OF INJURY OF THE MEAN CORRECTED COOLING RATES BEFORE AND AFTER NINETY DAYS POST-FROSTBITE

Degree of Injury	Mean Corrected Cooling Rate						t	P
	Before 90 Days			After 90 Days				
	No.	°C./min./°C.	S. D.	No.	°C./min./°C.	S. D.		
Control	6	.0247	± .0088	6	.0247	± .0088	—	—
0	15	.0348	± .0225	5	.0294	± .0069	0.818	>.40
1	14	.0362	± .0261	11	.0385	± .0282	0.209	>.80
2	23	.0309	± .0270	13	.0246	± .0139	0.926	>.30
3	18	.0192	± .0204	11	.0330	± .0267	1.468	>.10

When the cold exposure was terminated and the patients returned to the room with an ambient temperature of 22° C. their toes remained cold or were rewarmed slowly and passively by the warmer air. After a variable period of time active rewarming occurred. This was the sudden increase in skin temperature due to the release of vasoconstrictor tone in the digits in addition to the environmental heating. The toes of a few patients, especially those with third degree frostbite, were initially warmer than the ambient air and reached a peak in rewarming almost immediately. Others did not attain a temperature above that of the air within the entire 3-hour period of observation.

TABLE 13

COMPARISONS BETWEEN THE MEAN CORRECTED COOLING RATES OF THE GREAT TOES OF CONTROL AND PREVIOUSLY FROST-BITTEN SUBJECTS BEFORE AND AFTER NINETY DAYS POST-FROSTBITE

Degree of Injury of Toes Compared	Before 90 Days		After 90 Days	
	t	P	t	P
Control vs 0	1.485	>.10	1.000	>.30
" vs 1	1.474	>.10	1.500	>.10
" vs 2	0.925	>.30	0.019	>.90
" vs 3	0.917	>.30	0.943	>.30
0 vs 1	0.154	>.80	1.011	>.30
0 vs 2	0.481	>.60	0.980	>.30
0 vs 3	2.080	<.05	0.419	>.60
1 vs 2	0.589	>.50	1.495	>.10
1 vs 3	2.000	>.05	0.470	>.60
2 vs 3	1.581	>.10	0.944	>.30

When active rewarming did occur the skin temperature of the toes often increased as much as 5 to 10° C. in from 15 to 20 minutes (Figure 4). The mean time elapsed between the cessation of cooling and the onset of active rewarming for each

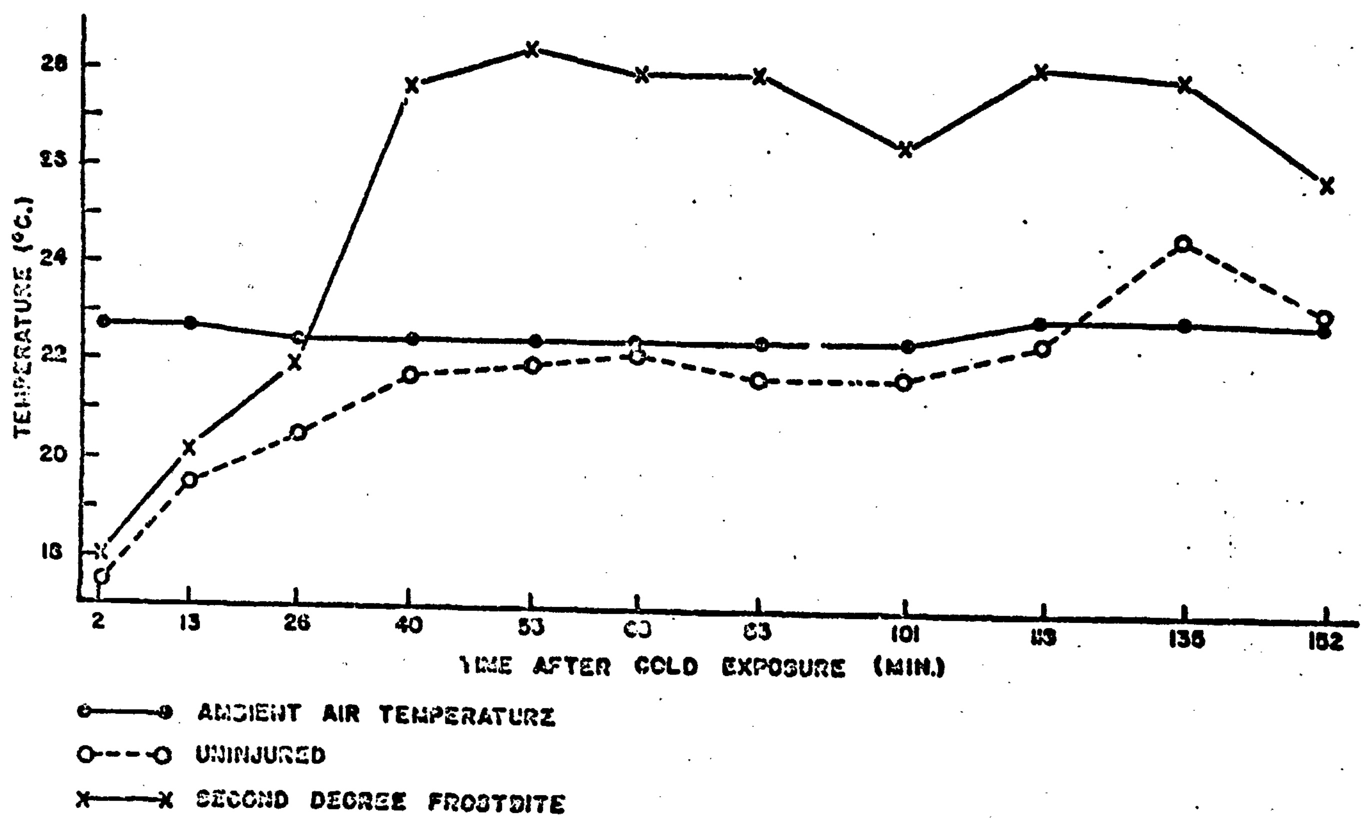


FIGURE 4. REWARMING CURVES OF THE GREAT TOES OF A PATIENT WITH UNILATERAL SECOND DEGREE FROSTBITE.

degree of injury in the five groups studied is recorded in Tabl. 14 together with the results of statistical comparisons between the two degrees of injury in each group. The number of tests in which active rewarming of either great toe did not occur is also shown. These cases were essentially equally distributed among the five combinations of lesions and were excluded from the analysis. When active rewarming occurred in only one great toe of a subject during the 3 hours of observation the time of rewarming for the other toe was arbitrarily set at 3 hours for the purpose of this study. The extreme variability in the rewarming of toes with any degree of injury was reflected in the standard deviations of the means. Only the values for toes with no injury and second degree frostbite, present in the same individual, showed a statistically significant difference. The latter rewarmed earlier than the uninjured toes.

TABLE 14

TIME OF ACTIVE REWARMING OF THE GREAT TOES OF PREVIOUSLY FROSTBITTEN PATIENTS FOLLOWING EXPOSURE TO COLD

Degree of Injury	Number of Tests Active Rewarming		Mean Time of Active Rewarming		t	P
	Present	Absent	Min.	S.D.		
0 2	12	2	77 38	± 61.2 ± 18.0	2.167	<.05
0 3	7	1	84 56	± 66.0 ± 49.2	0.903	>.30
1 2	11	3	54 85	± 25.2 ± 55.2	1.722	>.10
1 3	13	2	54 49	± 52.8 ± 50.4	0.250	>.80
2 3	10	3	79 61	± 60.0 ± 40.8	0.783	>.40

Due to the variability between individuals and the small number of observations these mean times of rewarming may be misleading. A study of the frequency with which a toe with a given degree of injury rewarmed earlier, simultaneously or later in respect to the contralateral toe which had a different degree of injury showed greater differences (Table 15). Rewarming was considered simultaneous unless the times of rewarming differed by 12 or more minutes, the approximate interval between temperature measurements. Uninjured toes tended to rewarm later than toes with second and third degree lesions which in turn showed a tendency to rewarm later than toes with first degree frostbite when present in the same subject. The incidence of delayed rewarming of second degree lesions was greater than that of third degree lesions when on opposing toes, but the difference was slightly less marked than in the other groups. The chi square test was just short of significance at the 5% level of probability, indicating that the rewarming of the lesser relative to the greater degree of injury in any of the combinations of lesions was not significantly different from that of the total. However, an analysis utilizing only the combined results of the two groups with an uninjured toe in common and the two groups with first degree lesions yielded a value for chi square of 13.726. With one degree of freedom the probability was less than 1% that the difference in the rewarming of toes with no injury and with first degree frostbite relative to that of toes with second and third degree frostbite was due to chance. The rewarming of second relative

to third degree lesions was intermediate between that of toes with no injury and those with first degree frostbite.

The elevation of the skin temperature at its peak during rewarming is recorded in Table 16 as the mean difference between the toe and ambient temperatures. These mean temperature gradients did not differ significantly between any two degrees of injury present in the same subject. The results of comparisons between the mean values for toes with a like degree of injury but with dissimilar lesions of the contralateral toes and with unlike degrees of injury but with the same severity of frostbite of the opposite toe (Table 17) corresponded closely to the same comparisons between the pre-exposure toe-ambient temperature gradients. In general, toes with third degree frostbite and

TABLE 15

FREQUENCY DISTRIBUTION OF THE RELATIVE TIME OF ACTIVE REWARMING OF THE GREAT TOES OF PREVIOUSLY FROSTBITTEN SUBJECTS

Degree of Injury of Contralateral Toes Compared	Time of Active Rewarming of Lesser Relative to Greater Degree of Injury:		
	Earlier	Simultaneous	Later
0 - 2	1	4	7
0 - 3	1	1	4
1 - 2	6	4	1
1 - 3	6	4	1
2 - 3	2	3	5
Totals	16	16	18
Chi square = 15.316 df = 8 P >.05			

toes with a lesser or no injury whose counterpart on the opposite foot had third degree frostbite rewarmed to a higher temperature

TABLE 16

MEAN TOE-AMBIENT TEMPERATURE DIFFERENCES OF THE GREAT TOES AT THE HEIGHT OF REWARMING FOLLOWING EXPOSURE TO COLD

Degree of Injury	Number of Tests	Mean Toe-Ambient Temperature Difference °C.	S. D.	t	P
0 2	10	3.6 4.0	± 1.33 ± 1.31	0.667	>.50
0 3	6	5.2 5.2	± 1.28 ± 2.01	—	—
1 2	9	3.8 4.6	± 1.27 ± 1.51	1.143	>.20
1 3	11	5.1 5.4	± 1.44 ± 1.35	0.500	>.60
2 3	8	4.9 5.4	± 0.69 ± 1.71	0.714	>.40

than the remainder.

The mean toe-ambient temperature gradients before exposure and at the peak of rewarming are compared in Table 18. The mean values for all degrees of injury in all five groups were higher after the cold exposure but the differences were significant or approached significance only in those groups composed of patients without a third degree lesion, that is, those with no injury and second degree, and those with first and second degree frostbite present in the same individual. These toes cooled most extensively during the pre-exposure equilibration period and even though their temperature was increased the most by the active rewarming following exposure to cold, they did not rewarm to as high a temperature as the others. The actual mean temperature at the peak of rewarming in an environment of 22.3° C.

TABLE 17

COMPARISONS BETWEEN THE MEAN TOE-AMBIENT TEMPERATURE GRADIENTS OF THE GREAT TOES OF PREVIOUSLY FROSTBITTEN SUBJECTS AT THE HEIGHT OF REWARMING FOLLOWING EXPOSURE TO COLD

Degree of Injury*	Number of Toes	Mean Toe-Ambient Temperature Difference °C.	S. D.	t	P
0 (2)	10	3.6	± 1.33	2.225	<.05
0 (3)	6	5.2	± 1.[illegible]		
1 (2)	9	3.8	± 1.27	2.167	<.05
1 (3)	11	5.1	± 1.[illegible]		
2 (0)	10	4.0	± 1.31	1.000) 1.000	>.30) >.05
2 (1)	9	4.6	± 1.31	0.500)	>.60)
2 (3)	8	4.9	± 0.[illegible]		
3 (0)	6	5.2	± 2.01	0.222) 0.200	>.80) >.80
3 (1)	11	5.4	± 1.35	0.000)	—)
3 (2)	8	5.4	± 1.[illegible]		
2 (0)	10	4.0	± 1.31	1.333	>.20
3 (0)	6	5.2	± 2.01		
2 (1)	9	4.6	± 1.31	1.333	>.10
3 (1)	11	5.4	± 1.[illegible]		
0 ([illegible])	10	3.6	± 1.[illegible]	0.333) 2.571	>.70) <.05
1 ([illegible])	9	3.8	± 1.27	2.2[illegible])	<.05
3 ([illegible])	8	5.4	± 1.[illegible]		
0 ([illegible])	6	5.2	± 1.[illegible]	0.2[illegible]) 0.500	>.[illegible]) >.60
1 (3)	11	5.1	± 1.[illegible]	0.[illegible])	>.[illegible])
2 (3)	8	4.9	± 0.69		

* The number in parentheses after the degree of injury denotes the degree of injury of the contralateral great toe.

was 26.1° C. for uninjured toes, 26.5° C. for toes with first degree, 26.6° C. for toes with second degree and 27.4° C. for toes with third degree frostbite.

IV. DISCUSSION

The post-cold injury syndrome is important clinically because of the vasoconstriction which characterizes it and the resultant decrease in blood flow through the part involved. The skin temperature of a toe is related to the total minute volume of blood flow through the digit under conditions such as those which prevailed in this study

TABLE 18

COMPARISONS BETWEEN THE MEAN TOE-AMBIENT TEMPERATURE GRADIENTS OF THE GREAT TOES OF PREVIOUSLY FROSTBITTEN SUBJECTS BEFORE AND AFTER EXPOSURE TO COLD

Degree of Injury	Mean Toe-Ambient Temperature Difference						t	P
	Before Cold Exposure			After Cold Exposure				
	No.	°C.	S.D.	No.	°C.	S.D.		
0 2	13	1.5 2.5	± 2.25 ± 2.0[illegible]	10	3.6 4.0	± 1.33 ± 1.31	2.625 2.[illegible]	<.02 <.05
0 3	7	4.6 [illegible].3	± 1.[illegible] ± 2.07	6	5.2 5.2	± 1.[illegible] ± 2.0[illegible]	0.[illegible] 0.[illegible]	>.50 >.[illegible]0
1 2	13	1.9 2.9	± [illegible] ± 3.[illegible]	9	3.[illegible] 4.5	± 1.[illegible] ± [illegible]	1.9[illegible] 1.[illegible]	>.05 >.10
1 3	12	4.2 4.7	± 2.[illegible] ± 2.[illegible]	11	5.1 5.4	± 1.[illegible] ± 1.35	0.[illegible] 1.[illegible]	>.[illegible]0 >.[illegible]0
2 3	10	4.2 5.3	± 2.[illegible] ± 2.[illegible]	3	4.9 5.4	± 0.[illegible] ± 1.[illegible]	1.[illegible] 0.111	>.[illegible]0 >.[illegible]0

(2,3). However, it does not necessarily reflect the <u>effective</u> blood flow, that part of the total which passes through true capillaries in distinction to that which flows through thoroughfare channels. It is only the former fraction of the flow that is available for exchange with the tissue. The skin temperature does allow an estimation of the circulatory status of a digit, however, and since it was the only technique available, it was employed in this study.

The degree to which the temperature of the skin approximates that of the environment, expressed here as the toe-ambient temperature gradient, is frequently used as an index of the state of the peripheral circulation in clinical practice. The variability of this measure even among persons with normal circulation limits its use as a diagnostic tool to unilateral disorders which permit direct comparisons between the abnormal and the normal extremity of the same individual. In the present study, therefore, it was not unexpected that the variability in

the results evidenced by the magnitude of the standard deviations relative to the means did not permit the digits to be classified in respect to the absence, presence or degree of frostbite on the basis of their toe-ambient temperature gradients. However, the mean gradients showed that there were group tendencies to either a greater or lesser degree of vasoconstriction among the various degrees of frostbite as compared to the controls.

The cooling rate is also an index of blood flow. Newton's empirical law of cooling is generally considered applicable to the cooling of digits under conditions such as those in this experiment. The law states that the temperature of a given warm body with constant thermal conductivity will decline along a curve having an exponential equation of the type:

$$T_t = T_o e^{-at},$$

T_o is the initial (zero time) difference between the temperatures of the body and the ambient air, T_t the temperature difference at any specified time, "t" and "a", the constant representing the cooling rate. If the skin temperature data are plotted semilogarithmically with the ordinate representing the skin-ambient temperature difference at time "t" indicated on the abscissa, a straight line results. Since the thermal conductivity of a digit is determined by the thermal conductivity of the tissue itself, which may be considered constant, and the blood flow through the digit, any differences between the slopes of the lines reflect corresponding differences in blood flow.

The blood flow through the digits studied was essentially constant during the first 50 minutes of exposure to cold. Any reduction in flow induced by the cold must have occurred almost instantaneously or at least so rapidly that it could not be detected by the technique

of intermittent skin temperature measurements employed. The "goodness of fit" of the temperature data to the calculated cooling curve, an index of the constancy of the blood flow, indicated that in 84% of the tests as good a fit could have been obtained by chance in less than 5% of repeated tests. In most of the instances in which the fit of the data to the theoretical cooling curve was poorer the probability was less than 10%. After 50 minutes of exposure cooling was no longer an exponential function of time but became asymptotic or erratic. This portion of the cooling curve was not utilized in the cooling rate calculations.

Sheard et al. (4) reported that the great toes of seven subjects, three with normal circulation and four with vasospastic or organic vascular disease, cooled at essentially the same rate in an ambient air temperature of 18° C. (64.4° F.). The range of cooling rates reported was from .02 to .05 degrees (C.) per minute. They explained the lack of diagnostic value of the cooling rate to an equal diminution of blood flow in normal and diseased extremities by vasoconstriction alone in the former and vasoconstriction superimposed on spasm or vascular occlusion in the latter. The results of the present study confirmed their opinion that the cooling rate is not diagnostic of peripheral vascular abnormality in the individual case. However, there is evidence that there is a tendency for the cooling rate to vary in proportion to the degree of vasoconstriction produced by a disturbance of the peripheral circulation when the mean value for a group of patients with such a lesion is compared with that for a group of normal subjects. For example, there was a tendency for toes with first degree frostbite to cool more rapidly on the average than the toes of the controls. The

results of the studies on control subjects, although admittedly tenuous because of the extremely small number of observations, suggested that the cooling rate increased as the ambient air temperature of the exposure decreased down to approximately 40° F.

While the ability of the cooling rate to distinguish different degrees of vasoconstriction may be limited, it certainly can differentiate an extremity afflicted with a condition which produces vasodilatation from one with normal or increased vasomotor tone. Third degree lesions during the first 90 days after frostbite cooled significantly slower than the uninjured toes of unilaterally frostbitten patients. Also the mean cooling rate of the toes of the control subjects at 35° F. was significantly lower than at 50° F. This was in agreement with the findings of Greenfield (5) and others (6) who demonstrated that vasodilatation occurs when an extremity is immersed in water at a temperature close to 0° C. They found the blood flow during this cold vasodilatation to be maximal. It is of interest that for 90 days after injury the cooling rates for the toes with the third degree frostbite at 50° F. was of the same order as that of the control toes at 35° F.

Within the limitations of the techniques employed the skin temperature studies have confirmed clinical impressions of the circulatory changes which occur in frostbitten patients. The analysis was handicapped by the small number of tests. The interpretation of the results was also complicated by the influence upon the response of a toe with any one degree of injury by the dissimilar lesion of the contralateral toe. Any attempt to discriminate between the responses of the various degrees of injury was further complicated by the arbitrary and superficial nature of the clinical classification of severity of frost-

bite. This was particularly true of the distinction between second and third degree lesions. This division is based only on the depth of skin loss. A severe second degree injury is therefore often differentiated from a mild third degree lesion by the survival of a few epithelial cells. The damage to the deeper structures may be identical in the two instances. The classification, furthermore, does not take into consideration the extent of involvement which may be an important factor in determining the subsequent vascular responses.

Nevertheless, the skin temperature observations showed that toes with third degree frostbite were in a state of vasodilatation for an appreciable length of time after injury. These toes thereafter showed evidence of excessive vasoconstriction upon exposure to cold of the same order as that initially exhibited by toes with less severe frostbite. The tests were not performed in sufficient number early enough after injury to demonstrate the initial brief warm phase observed clinically in the latter cases. Some evidence was elicited to suggest that the exaggerated response to cold exhibited by toes with first and second degree frostbite gradually decreased with time. This finding is in agreement with clinical observations that the morbidity due to the post-frostbite sequela progressively decreases.

The temperature observations did not contribute materially to the understanding of the pathology of this sequela to frostbite. The history of the lesion, however, suggested a hypothesis which might profitably be subjected to investigation. Evidence has been reported in support of the view that capillary blood flow is controlled by an enzyme system which inactivates circulating nor-epinephrine or possibly epinephrine at the pre-capillary sphincters (6). If this system were

destroyed or damaged by cold injury a normally sub-threshold concentration of the humoral vasoconstrictor substance could become effective and the action of an effe tive concentration would be prolonged. This would have the effect of "sensitizing" the vessels locally to cold stress and produce the manifestations of the post-cold injury syndrome. Such a departure from normal physiology must be assumed to involve third degree as well as first and second degree lesions. The difference in the response of the former during the immediate post-injury period may be explained on the basis of an additional insult to the innervation of the part involved. The duration of this initial period of vasodilatation (up to 3 months after injury) was commensurate with the time required for the recovery of damaged nerves.

The time of rewarming of the toes did not present a pattern of response in respect to degree of injury which could be explained with any assurance. The results were extremely variable. One feature of interest in the rewarming responses, regardless of degree, was the length of time required for active rewarming to occur. The mean value for each degree was at least 30 minutes and about an hour in the majority of instances. The delay in rewarming may have been due to a diminution of the number of functioning capillaries as a result of the prolonged action of the humoral vasoconstrictor substance at the pre-capillary sphincters. This view was supported by the observation frequently made in these tests that cyanosis of the skin of the toes was replaced by a deep red color an appreciable length of time before the temperature increased. Oxygenated blood was reaching the sub-papillary venous plexuses. However, apparently due to the persistence of spasm of the pre-capillary sphincters it was not passing through the superficial

capillaries and consequently the surface temperature was not immediately affected.

It is not known whether or not the duration of the post-cold injury syndrome is compatible with the time the enzyme system would require to recover or be replaced if indeed it would recover. Perhaps investigation of previously frostbitten subjects to determine the response to the injection of epinephrine would be of value in deciding this point. Similarly, studies of the effect of parenterally administered ferrous ion or ferritin (7,8) which have been shown to raise the threshold of the pre-capillary sphincters to epinephrine, would be of interest.

V. SUMMARY AND CONCLUSIONS

Skin temperature studies were performed before, during and after exposure to cold of previously frostbitten and control subjects. The results, in general, substantiated clinical impressions of the changes in the circulation of the involved toes which have been observed after frostbite. Shortly after injury these digits showed excessive vasoconstrictor tone which was modified in the case of the severest injuries by what appeared to be cutaneous denervation of the involved part. A hypothetical explanation of these findings has been advanced.

The cold stress test is an effective means of eliciting evidence of the post-frostbite syndrome. The use of this test should aid in determining the pathology involved and in the evaluation of therapeutic measures. Skin temperature measurements alone were not of material aid in this respect.

VI. BIBLIOGRAPHY

1. Orr, K. D. and D. C. Fainer. Cold injuries in Korea during winter of 1950-51. Medicine 31: 177, 1952.

2. Macht, H. B. The effects of various amino acids on peripheral blood flow and skin temperature. J. Clin. Investigation 27: 454, 1948

3. Fetcher, E. S., J. F. Hall, Jr. and H. G. Shaub. The skin temperature of an extremity as a measure of its blood flow. Science 110: 422, 1949.

4. Sheard, C., B. T. Horton and M. M. D. Williams. Rates of cooling and warming of extremities in normal circulatory conditions and in peripheral vascular diseases. Proc. Staff Meet. Mayo Clin. 14: 541, 1939

5. Greenfield, A.D.M., G. A. Kernohan, R. J. Marshall, J. T. Shephard and R. F. Whelan. Heat loss from toes and fore-feet during immersion in cold water. J. Appl. Physiol. 4: 37, 1951.

6. Ferrer, M. I. Cold injury - Transactions of the first conference June 4-5, New York, Josiah Macy, Jr. Foundation, p. 172, 1951.

7. Crismon, J. M. Depression of capillary responses to epinephrine by ferrous iron. Federation Proc. 9: 25, 1950.

8. Mazur, A., I. Litt and E. Shorr. The relationship of sulfhydryl groups in ferritin to its vasodepressor activity. J. Biol. Chem. 187: 485, 1950.

APPENDIX I

TABLES OF CORRELATIONS BETWEEN TIME AFTER INJURY AND CORRECTED COOLING RATES

APPENDIX TABLE 1

CORRELATION BETWEEN THE TIME AFTER INJURY AND THE CORRECTED COOLING RATE OF THE UNINJURED GREAT TOES OF PATIENTS WITH UNILATERAL SECOND DEGREE FROSTBITE

Degree of Injury: 0(2)	
Time After Injury (days)	Corrected Cooling Rate (°C./min./°C.)
39	.0354
48	.0141
63	.0244
65	.0193
65	.0847
68	.0394
77	.0494
86	.0035
93	.0358
107	.0339
114	.0215
123	.0314
127	.0245
rho = - .015	

APPENDIX TABLE 2

CORRELATION BETWEEN THE TIME AFTER INJURY AND THE CORRECTED COOLING RATE OF THE UNINJURED GREAT TOES OF PATIENTS WITH UNILATERAL THIRD DEGREE FROSTBITE

Degree of Injury: 0(3)	
Time After Injury (days)	Corrected Cooling Rate (°C./min./°C.)
15	.0235
47	.0156
55	.0680
59	.0419
71	.0487
75	.0175
88	.0373
rho = + .143	

APPENDIX TABLE 3

CORRELATION BETWEEN THE TIME AFTER INJURY AND THE CORRECTED COOLING RATE OF GREAT TOES WITH FIRST DEGREE FROSTBITE OF PATIENTS WITH SECOND DEGREE FROSTBITE OF THE CONTRALATERAL GREAT TOES

Degree of Injury: 1(2)	
Time After Injury (days)	Corrected Cooling Rate (°C./min./°C.)
30	.0256
34	.0530
42	.0057
54	.0913
56	.0235
65	.0467
66	.0701
77	.0593
81	.0131
95	.0595
105	.0401
116	.0337
128	.0124
rho = -.082	

APPENDIX TABLE 4

CORRELATION BETWEEN THE TIME AFTER INJURY AND THE CORRECTED COOLING RATE OF PATIENTS WITH THIRD DEGREE FROSTBITE OF THE CONTRALATERAL GREAT TOES

Degree of Injury: 1(3)	
Time After Injury (days)	Corrected Cooling Rate (°C./min./°C.)
32	.0174
45	.0315
63	.0331
65	.0057
89	.0316
97	.0109
102	.0089
111	.0226
114	.0802
125	.0165
128	.0649
137	.0737
rho = +.371	

APPENDIX TABLE 5

CORRELATION BETWEEN THE TIME AFTER INJURY AND THE CORRECTED COOLING RATE OF GREAT TOES WITH SECOND DEGREE FROSTBITE OF PATIENTS WITH UNILATERAL FROSTBITE

Degree of Injury: 2(0)	
Time After Injury (days)	Corrected Cooling Rate (°C./min./°C.)
39	.0428
48	.0334
63	.0030
65	.0330
65	.0293
68	.0391
77	.0558
86	.0022
93	.0388
107	.0562
114	.0234
123	.0254
127	.0246
rho = -.205	

APPENDIX TABLE 6

CORRELATION BETWEEN THE TIME AFTER INJURY AND THE CORRECTED COOLING RATE OF GREAT TOES WITH SECOND DEGREE FROSTBITE OF PATIENTS WITH FIRST DEGREE FROSTBITE OF THE CONTRALATERAL GREAT TOES

Degree of Injury: 2(1)	
Time After Injury (days)	Corrected Cooling Rate (°C./min./°C.)
30	.0336
34	.0210
42	.0391
54	.1071
56	.0214
65	.0217
66	.0255
77	.0008
81	.0119
95	.0060
105	.0142
116	.0108
128	.0186
rho = -.698	

APPENDIX TABLE 7

CORRELATION BETWEEN THE TIME AFTER INJURY AND THE CORRECTED COOLING RATE OF GREAT TOES WITH SECOND DEGREE FROSTBITE OF PATIENTS WITH THIRD DEGREE FROSTBITE OF THE CONTRALATERAL GREAT TOES

Degree of Injury: 2(3)	
Time After Injury (days)	Corrected Cooling Rate (°C./min./°C.)
27	.0135
56	.0018
56	.0274
58	.0256
67	.0191
78	.0973
101	.0177
114	.0278
117	.0184
129	.0377
rho = +.482	

APPENDIX TABLE 8

CORRELATION BETWEEN THE TIME AFTER INJURY AND THE CORRECTED COOLING RATE OF GREAT TOES WITH THIRD DEGREE FROSTBITE OF PATIENTS WITH UNILATERAL FROSTBITE

Degree of Injury: 3(0)	
Time After Injury (days)	Corrected Cooling Rate (°C./min./°C.)
1[illegible]	.0410
47	.0091
55	.0702
59	.0366
71	.0327
75	.0101
98	.0185
rho = -.357	

APPENDIX TABLE 9

CORRELATION BETWEEN THE TIME AFTER INJURY AND THE CORRECTED COOLING RATE OF GREAT TOES WITH THIRD DEGREE FROSTBITE OF PATIENTS WITH FIRST DEGREE FROSTBITE OF THE CONTRALATERAL GREAT TOES

Degree of Injury: 3(1)	
Time After Injury (Days)	Corrected Cooling Rate (°C./min./°C.)
32	+.0005
45	.0019
63	.0358
65	.0025
89	.0029
97	.0140
102	.0318
111	.0215
114	.0210
125	.0134
128	.0206
137	.0421
rho = +.587	

APPENDIX TABLE 10

CORRELATION BETWEEN THE TIME AFTER INJURY AND THE CORRECTED COOLING RATE OF GREAT TOES WITH THIRD DEGREE FROSTBITE OF PATIENTS WITH SECOND DEGREE FROSTBITE OF THE CONTRALATERAL GREAT TOES

Degree of Injury: 3(2)	
Time After Injury (days)	Corrected Cooling Rate (°C./min./°C.)
27	.0192
56	+.0080
56	.0078
58	.0318
67	.0013
78	.0315
101	.0197
114	.0378
117	.0371
129	.[illegible]
rho = +.785	

ARMY MEDICAL RESEARCH LABORATORY

FORT KNOX, KENTUCKY

REPORT NO. 113
1 April 1953

COLD INJURY - KOREA 1951-52*

Section XII
THE ASCORBIC ACID STATUS OF NORMAL SOLDIERS AND FROSTBITE CASUALTIES, KOREA, 1951-52

*Subtask under Environmental Physiology, AMRL Project No. 6-64-12-028, Subtask (8K), Cold Injury Studies.

MEDICAL RESEARCH AND DEVELOPMENT BOARD
OFFICE OF THE SURGEON GENERAL
DEPARTMENT OF THE ARMY

SECTION XII

THE ASCORBIC ACID STATUS OF NORMAL SOLDIERS AND FROSTBITE CASUALTIES

KOREA, 1951-52

by

Louis J. Polskin
Capt., MC, AUS

and

Kenneth D. Orr
Lt. Col., MC, USA

TABLE OF CONTENTS

THE ASCORBIC ACID STATUS OF NORMAL SOLDIERS
AND FROSTBITE CASUALTIES
KOREA, 1951-52

I. INTRODUCTION

Studies with rats and guinea pigs have revealed an intimate relationship between cold acclimatization and the concentration of ascorbic acid in the endocrine glands, particularly in the adrenals (1). In a study by Dugal and Fortier (2), adult male monkeys, receiving a basal diet which was fortified daily with 325 mgm. of ascorbic acid, showed better acclimatization and resistance to a cold environment than those given daily only a 25 mgm. supplement of vitamin C. No analyses of the ascorbic acid levels in the blood, urine or tissues of these animals were made. In three treatises of 1950-51 (3,4,5) only meager information is noted regarding the alterations of vitamin C metabolism in man under stress of cold. A study of the effects of cold on man, based largely on psychomotor and visual efficiency tests, was made by Glickman et al.(6). They noted that extra supplement of ascorbic acid did not enhance the ability of their subjects to withstand exposures "either to intense cold (-20° F.) with protective clothing, or to moderate coolness (60° F.) with very little clothing".

It is logical to study the vitamin C status of soldiers afflicted with cold injuries to determine whether or not there is a relationship between man's resistance to cold and his body stores of ascorbic acid. During the winter of 1951-52 there was an opportunity to determine the vitamin C status of large numbers of troops before and after exposure to the environment of front-line combat during cold weather.

II. SURVEY OF FOOD HABITS OF THE FROSTBITE CASUALTIES

Upon admission to the Osaka Army Hospital, 116 patients with varying degrees of frostbite were interviewed regarding their food intake while stationed in Korea. These 116 cases of frostbite arrived at Osaka from 3 to 54 days (average 9.6 days) after injury in Korea.

A. Type of Food 24 Hours Prior to Frostbite

The theater field ration (B Ration) was the sole source of food for 29 men. A combination of the field ration and packaged rations for at least one meal was supplied to 47 soldiers, among whom 42 were given combat ration (C Ration) and 5 the Individual Assault Ration. There were 40 soldiers who subsisted on packaged rations exclusively during the 24 hours preceding frostbite. The combat ration was supplied to 34 of these 40 men, the Individual Assault Ration to 5 and the Frigid Trail Ration to one individual. Of the 34 soldiers who subsisted on combat rations exclusively, 30 recalled all the individual items which were consumed during the 24 hours preceding frostbite. It was of interest that 20 of these 30 subjects subsisted on combat rations exclusively for 4 to 7 days prior to frostbite, and two were required to eat this ration longer than one week, namely, for 9 and 12 days.

The combat ration was designed to supply approximately 3,400 calories in one day.* The ascorbic acid content was 112 mgm. Nearly 100 of the 112 mgm. (89%) of the vitamin C was contained

*Data from "Operational Rations Used by the Armed Forces" and "Quartermaster Corps Purchase Description Records of Nutritive Values". 9 August 1950. The Quartermaster Food and Container Institute, Inc., Chicago, Illinois.

in the three assortments of "bread type" cans (called B-units) and in the Accessory Packet. Either the soluble coffee in the Accessory Packet or the cocoa powder in the B-1 unit was fortified with 30 mgm. of ascorbic acid. The soluble coffee contained in the B-1, B-2 or B-3 unit was fortified with 15 mgm. of vitamin C.

B. Caloric and Vitamin C Intake Prior to Frostbite

Although the type of ration was recalled, 18 of the 116 soldiers could not remember specific items of food eaten 24 hours before frostbite, and 67 (57%) had forgotten the items of food eaten on the second day preceding their cold injury. Six soldiers who were interviewed upon arrival at the Osaka Army Hospital, and re-surveyed on the third day, gave divergent statements regarding the individual food items which were eaten in Korea during the day preceding frostbite.

The 30 frostbite patients who recalled the individual items of the combat ration, revealed the following intakes per man during 24 hours prior to cold injury:

2.2 cans of meat-type foods
1.7 cans, called "B-units" (namely, crackers, cookies, jams, beverage powders and candy)
0.2 cans of fruit
1 to 3 candy bars

An estimate of this intake was 1800 calories and approximately 50 mgm. of ascorbic acid. Since 22 of the 30 men were on this ration solely for 4 to 12 days, such average intakes might have prevailed for longer than 24 hours. From the quantities of combat ration consumed on the front lines 24 hours prior to frostbite, it was concluded that these 30 soldiers ingested

less than one half of the normal requirement of calories.

In reviewing the diets eaten 24 hours prior to frostbite, it was found that 55 subjects (26 Negro, 25 White and four Puerto Ricans) recalled the individual items of the combat ration which comprised a single meal. From the consumption of the bread-type (B-unit) items, one could deduce grossly to what extent ascorbic acid was ingested during the single meal.

Only the B-units which were supplied to 26 Negroes and 25 Whites during the 24 hours preceding frostbite were considered. There was relatively equal opportunity for accepting the coffee powder, cocoa and jam contained in the B-units. The percent acceptance of coffee powder by White and Negro soldiers was 25.0 and 10.3, respectively; the percent acceptance of cocoa powder was 64.3 and 33.3, respectively (Table 1). The percent acceptance of jam by White and Negro subjects was 88.0 and 75.0, respectively. None of the differences between White and Negro percentages of acceptance were found to be significant. The most acceptable item, namely, the jam contained only 2 mgm. of ascorbic acid. The coffee and cocoa powders, fortified with 15 and 30 mgm. of vitamin C, respectively, were frequently discarded, along with the sugar and milk powder (contained in the B-units). Other items available in the B-units (cookies, crackers and candy) although containing no or insignificant amounts of vitamin C were rarely discarded.

The individual daily intake of water for 116 patients ranged

TABLE 1

ACCEPTABILITY OF ASCORBIC ACID FORTIFIED ITEMS OF THE COMBAT RATION ISSUED 24 HOURS PRIOR TO FROSTBITE

Food item and its Ascorbic Acid content	Race	Total items supplied to soldiers	No. of Accept-ances	Percent of Accept-ances	No. of S. E. in Difference
Coffee powder; 15 mgm. ascorbic acid	White	36	9	25.0	1.7
	Negro	39	4	10.3	
Jam; 2 mgm. ascorbic acid	White	25	22	88.0	1.2
	Negro	24	18	75.0	
Cocoa powder; 30 mgm. ascorbic acid	White	14	9	64.3	1.5
	Negro	9	3	33.3	

from 0.75 to 3.0 liters per day with a mean intake of 1.1 liters.

C. Discussion

The evaluation of nutrition by the technique of survey is difficult. The data give presumptive information in the light of many uncontrollable factors, such as economic status, occupation, climate, clothing, age, sex, food customs, state of health and the like. A survey in an army might be more valid, since the population is representative of every section of the United States, and certain of the aforementioned factors encountered in civilian surveys are absent. However, such variables as the physiologic and psychologic stress of battle, weather, fear, food habits and capacity of memory, should be weighed in the final interpretation of the findings.

The reduced caloric intake of the soldier while subsisting on partial combat rations is much more critical from a nutritional, and from a military, point of view than is the

sole omission of vitamin C. The importance of adequate caloric intake in cold weather for as brief a period as 2 to 3 days was exemplified among soldiers in the reports of Kark, Johnson and Lewis (7,8). A toughened, healthy platoon of 17 infantrymen, on maneuvers under subarctic winter conditions, subsisted solely on beef pemmican (dehydrated prime beef with added suet), tea and tobacco. The intake approximated 1,500 to 1,700 calories (comparable to the intakes of the 30 cases of this report) while the work output was about 4,500. The vitamin C content of the ration was zero. Within 48 to 72 hours the morale and physical fitness deteriorated so as to render the men "completely useless operationally". They felt the cold keenly in contrast to their usual good adaptation to outdoor temperatures as low as -30° F. With supplements of biscuits, oatmeal, milk and condiments recovery was reasonably good, but full vigor was not manifested until given a week of rest on garrison rations. It was interesting to note that ascorbic acid, eliminated in the fasting urine, unlike the members of the vitamin B complex (thiamine, riboflavin and nicotinic acid) fell from 0.7 mgm. per hour before the test, to 0.4 mgm. per hour after 3 days of ration. Blood levels, however, were not reported.

The results of the 1951-52 winter survey relative to food habits, although gleaned from a small number of casualties, suggested strongly that the frostbitten front-line soldier (subsisting exclusively on the combat ration) was perhaps

handicapped by insufficient calories. Concomitantly, his vitamin (and particularly, vitamin C) intake was reduced. The main sources of ascorbic acid in the combat ration were fortified foods which were poorly relished by these soldiers. Since 22 of 30 soldiers interviewed had combat rations exclusively for more than 24 hours, the findings with respect to the ingestion of calories and vitamin C take on added significance.

The discarding by soldiers of the vitamin C fortified foods, namely, coffee and cocoa powders, recalls a similar situation in World War II. The main source of ascorbic acid supplied to troops in Dutch New Guinea (9) and in Italy (10) was obtained in a synthetic lemon powder. This item was not relished, and it was discarded by an overwhelming majority of the men. Moreover, both normal personnel and random hospital admissions showed low levels of vitamin C in the blood.

III. ORAL LOADING ("SATURATION") TESTS WITH ASCORBIC ACID

To gain more information regarding the vitamin C stores in soldiers afflicted with frostbite, loading tests were started immediately upon admission to the Osaka Army Hospital in Japan. According to the saturation theory, "the highest health and efficiency are achieved when loading tests reveal a high level of vitamins in the body" (11). From the quantity necessary to maintain saturation, one may deduce that satisfactory to optimum requirements may lie proportionately below this amount.

In the usual "saturation" technique reported in the literature, there is induced a sudden flooding of the body stores with several hundred

to a thousand milligrams of ascorbic acid by oral, but more usually by parenteral, means. The amount of vitamin C in urine, blood or both is determined after one to several hours following the test dose. The studies reported here were conservative, if not therapeutic in design, supplying orally 250 mgm. of preformed vitamin C daily. These loading trials were not of the short-term"flooding" type, but based rather on analyses of fasting sera and the corresponding urines 24 hours after the administration of the vitamin. From a nutritional point of view such an approach may give better proof of saturation.

Between December 1951 and April 1952 a total of 95 saturation studies were completed, 43 being with White patients, 47 with Negro and five with Puerto Ricans. These patients were evacuated in small numbers by air from the Cold Injury Center in Korea to Osaka, Japan, resulting in a staggering of the loading trials throughout the winter. Based on the final diagnoses 41 had second degree, 35 third degree and 15 fourth degree frostbite. Of the remaining four subjects, two had first degree frostbite (the mildest category) and two the "ill-classified condition of the feet". The studies usually extended for a month with extremes of termination varying from 2.5 to 6 weeks.

It is emphasized that the data did not begin with the first post-injury day in Korea, but on an average of 9.6 days later, after the casualty was evacuated to Japan. The interval between the occurrence of frostbite in Korea and the initiation of loading tests in Osaka, Japan, ranged from 3 to 54 days. Comparing the Whites and Negroes, the interval between the occurrence of cold injury and evacuation to Japan was relatively equal. The determinations of ascorbic acid in sera and urines of 95 frostbite patients in relation to time of ad-

mission to the Osaka Army Hospital were as follows:

Days of Admission	Patients	Sera Analyses	Urine Analyses
1	80	80	69
2	1	1	1
4	1	1	1
5	10	10	10
8	3	3	3

Fifteen of the preceding 95 patients had subsisted on the hospital diet for 2 to 8 days before the first determination of ascorbic acid in their sera and urines was made. Only the data of 80 subjects, examined on the first day of admission and serially to the ninth day, are stressed in this report. The results before, and after, supplementation with ascorbic acid are discussed separately.

A. Dietary Plan

The "basal period" or "pre-saturation period" in this study refers to the number of days which the frostbite patients subsisted on standard hospital diets without vitamin supplements. For 86 of the 95 subjects this basal period lasted from 3 to 9 days and for the remainder from 3 to 15 days. On three separate mornings determinations of the ascorbic acid content of fasting blood and urine were made. These values are referred to as "basal determinations".

After basal determinations of the ascorbic acid content of the blood and urine were made, each patient was started on the saturation test by being given two tablets of vitamin C of 50 mgm. each and two multivitamin tablets following breakfast. The total preformed vitamin C supplied daily was 250 mgm. The patients were served three hot meals and an evening snack in bed. Using the food values listed by Bowes and Church (12),

the average daily caloric intake according to the daily menu between December 1951 and March 1952 ranged from 3,704 to 3,940 calories with a mean of 3,829. This total does not include the candy and beverage purchased by the individual patient from the hospital post exchange. The ascorbic acid content of the hospital diets ranged from 157 to 203 mgm. daily with a mean of 184 mgm. The actual intake values were presumably much less when one considers a kitchen and plate waste of approximately 22% of the caloric value of edible food and destruction of vitamin C in storing, processing, cooking and warming of food on the steam table (13). Such losses may approach 35 to over 70% (12,14,15,16,17,18). The food samples were not analyzed in this study.

In summary, the frostbite casualty was supplied (but did not necessarily ingest) approximately 184 mgm. of ascorbic acid from the unsupplemented hospital regime during the basal period and then a total of 434 mgm. (184 plus 250) daily for the remainder of his hospitalization. This is over eight times the daily level recommended for normal individuals by Army Regulation 40-250, over four times that by the National Research Council (19) and more than 14 times that recommended by the Canadian Council on Nutrition (20) or British Accessory Food Factors Committee (21). Both the American and Canadian councils have indicated that the daily requirement for ascorbic acid namely 75 and 30 mgm., respectively, "are without adding margins of safety of additions for illness or injury".

B. Experimental Procedure

The determination of vitamin C in serum, urine and vesicular

fluid, as well as the procedure of collecting fasting urine in the field, is described in the text, "Metabolic Methods" (22). Ascorbic acid was measured by a micromethod, titrating the metaphosphoric acid filtrates with the dye, 2-6 dichlorophenolindophenol. With each group of blood samples, the dye was standardized against a weighed amount (100 mgm.) of crystallin vitamin C (Merck).

When the problem of measuring ascorbic acid in urine arose it was agreed that analyses of the fasting hourly urinary elimination rather than 24 hour collections would be expedient for the following reasons:

1. Collection errors

   The shorter the period, the greater the accuracy in quantitative collection of urine of bed patients.

2. Oxidation of vitamin C in the urine

   In specimens r ᐧaining at an average ward temperature of 70°-74° F. for 24 hours the factor could be altered by possible bacterial contamination.

3. Less disturbance of the patients

   In order to obtain the best cooperation, it was desirable to minimize the duration of the study since the casualty also was subjected to other tests and medications which could affect urinary output.

The field method for collecting fasting urine is designed for ambulatory subjects, and proposes the ingestion of "at least one half pint of water, in order to insure diuresis" after a 60 to 90 minute period. This amount was insufficient for the frostbite bed-patient. The bed patients had difficulty

in emptying the bladder on demand and the urine volumes were usually very low. To await additional quantities of urine would delay breakfast until late in the morning and interfere with other hospital routines. For these reasons, 1 to 1 1/2 pints of water were ingested to obtain an adequate amount of urine within 60 to 90 minutes. The following procedure was used. Before breakfast, at 0730 hours, the individual emptied his bladder and the urine was discarded. A venous sample of blood was drawn. The time was noted when he drank the water and when he voided 60 to 90 minutes later. The total volume was recorded, and an aliquot was preserved with oxalic acid. The sample was stored in a refrigerator until subsequent analysis that same morning. Duplicate aliquots (0.1-0.5 cc.) were titrated with the dye solution. For sera, the titrations of the filtrates, although in duplicate, were performed from a single blood specimen. All tests were performed by one individual (L.J.P.), and the fleeting end-points of the titration agreed within 0.1 ml.

Although food was omitted between 1930 hours (the bed-time snack) and 0730 hours, water was not limited. The word "fasting" (e.g. fasting serum or fasting urine) is to be interpreted with this reservation. The concentration of ascorbic acid in serum is expressed as "milligrams (mgm.) per 100 cc". The quantity of ascorbic acid eliminated in the fasting urine is expressed as the total "milligrams per hour". This hour refers to the 60 minutes immediately preceding the end of the 12 hour fast, and it is not to be interpreted as an amount which was excreted hourly during any other time of day.

Since the normal value of ascorbic acid in the serum of adult humans is not clearly established in the literature the following ratings were arbitrarily made:

"Poor" - 0.39 mgm. per 100 cc. or less
"Fair" - 0.40 to 0.79 mgm. per 100 cc.
"Satisfactory" - 0.80 to 0.99 mgm. per 100 cc.
"Excellent" - 1.00 mgm. per 100 cc. or higher

C. Results

1. Pre-loading values

The mean ascorbic acid concentration of the fasting sera of 80 patients on admission to the Osaka Army Hospital was 0.60 mgm. per 100 cc. (Table 2). Comparisons between the

TABLE 2

INITIAL MEAN SERUM ASCORBIC ACID LEVELS FOR 80 FROSTBITE PATIENTS

Race	No. of Patients (Fasting)	Mean Serum Ascorbic Acid mgm/100 cc.	Standard Deviation
White	34	0.63	± 0.337
Negro	41	0.56	± 0.273
Puerto Rican	5	0.74	± 0.672
Combined (Grand Mean)	80	0.60	± 0.327

mean values of White and Negro subjects showed them not to be significantly different (Table 3). Table 4 shows comparisons of levels of ascorbic acid in sera of 80 subjects tested on their first day of hospitalization and during the basal period. The averages decreased from 0.60 mgm. per 100 cc. on day 1, to 0.51 mgm. on day 3 and then rose to 0.72 mgm. toward the end of the test period. The only alteration among these values showing statistical

TABLE 3

RACIAL COMPARISONS OF INITIAL MEAN SERUM ASCORBIC ACID VALUES FOR 80 FROSTBITE PATIENTS

Race	No. of Cases (Fasting)	Mean Serum Ascorbic Acid mgm/100 cc.	Standard Deviation	t	P
White Negro	34 41	0.63 0.56	± 0.337 ± 0.273	0.975	>.30
Negro Puerto Rican	41 5	0.56 0.74	± 0.273 ± 0.672	0.593	>.50
White Puerto Rican	34 5	0.63 0.74	± 0.337 ± 0.672	0.356	>.70

TABLE 4

COMPARISON OF DAILY MEAN SERUM ASCORBIC ACID VALUES OF 80 FROSTBITE PATIENTS WITH RESPECT TO NUMBER OF DAYS SUBSISTING ON ARMY HOSPITAL DIET

Days After Admission	Subjects (Fasting)	Mean Serum Ascorbic Acid mgm/100 cc.	Standard Deviation	t	P
1 2	80 79	0.60 0.59	± 0.327 ± 0.287	0.206	>.90
1 3	80 73	0.60 0.51	± 0.327 ± 0.270	1.863	>.10
1 4-5	80 10	0.60 0.69	± 0.327 ± 0.362	0.749	>.50
1 6-9	80 12	0.60 0.72	± 0.327 ± 0.280	1.556	>.20
2 3	79 73	0.59 0.51	± 0.287 ± 0.270	1.774	>.10
2 4-5	79 10	0.59 0.69	± 0.287 ± 0.362	0.840	>.50
2 6-9	79 12	0.59 0.72	± 0.287 ± 0.280	1.731	>.10
3 4-5	73 10	0.51 0.69	± 0.270 ± 0.362	1.515	>.20
3 6-9	73 12	0.51 0.72	± 0.270 ± 0.280	2.804	<.01
4-5 6-9	10 12	0.69 0.72	± 0.362 ± 0.280	0.225	>.90

significance, however, was that between the lowest and highest values, corresponding to day3 and days 6 to 9, respectively.

The grand mean of 263 analyses made on 80 patients during the pre-saturation period was 0.58 mgm. of vitamin C per 100 cc. of serum. In contrast, the grand mean value of 52 sera analyses of ascorbic acid made for 15 additional patients whose studies began between the second and eighth day of hospitalization and terminated between the fifth and fifteenth day before beginning the loading trials with vitamin C, was 0.68 mgm. per 100 cc. This average of 0.68 mgm. was significantly higher than the mean of 0.58 mgm. noted for the analyses of the 80 subjects ($t = 2.638$; $P < .001$). From a nutritional rating, however, these means (0.58 and 0.68 mgm.) are of the same order and were not saturated according to many values cited in the literature. The data of the 80 subjects suggest that during the basal test period of nine days the diet alone maintained or slightly improved the vitamin C concentrations of the blood as noted on the first day of hospitalization. The difference of the means throughout the basal period, either for the 80 subjects or the remaining 15, did not vary by more than 0.2 mgm. ascorbic acid per 100 cc.

The distribution of 315 analyses of fasting sera of 95 patients examined during the basal period is shown in Table 5. Fairly equal representation of the values was found among the White and Negro subjects. The lowest levels of serum ascorbic acid, namely, 0.15 to 0.39 mgm., appeared in 30% of the analyses and

were shown by 28 of the 95 patients. Likewise, 19 of the 95 casualties showed initial sera concentration of 0.85 to 1.50 mgm. of ascorbic acid per 100 cc. which were rated satisfactory to excellent. During the basal test period the values exhibited by these 19 men remained essentially unchanged. The single highest fasting serum level noted among the Negroes, Whites and Puerto Ricans was 1.30, 1.46 and 1.50 mgm. of vitamin C per 100 cc., respectively.

TABLE 5

DISTRIBUTION OF SERUM ASCORBIC ACID VALUES FOR 95 FROSTBITE PATIENTS SUBSISTING FOR 9 DAYS ON ARMY HOSPITAL DIETS

Rating With Respect to Vitamin C	Range of Serum Ascorbic Acid mgm/100 cc.	Analyses For 32 Whites	Analyses For 47 Negroes	Analyses For 5 Puerto Ricans	Total Analyses No.	Total Analyses %
Poor	0.15 to 0.39	38	48	8	94	30.0
Fair	0.40 to 0.79	65	70	4	139	44.0
Satisfactory	0.80 to 0.99	19	25	1	45	14.0
Excellent	1.00 to 1.50	21	12	4	37	12.0

Only 69 individual samples of fasting urine were collected from the 80 patients whose sera were analyzed on the first day of hospitalization in Osaka. The mean milligrams of vitamin C eliminated in the urine during the fasting hour was 1.47 (Table 6). Comparison of the mean levels of ascorbic acid in urines of these 69 patients in accordance with race demonstrated no significant differences (Table 7). When the levels of ascorbic acid in the sera of Whites and non-Whites, respectively, were compared with the corresponding amounts of vitamin C eliminated in the urine, no correlation was demon-

TABLE 6

INITIAL MEAN HOURLY URINARY ASCORBIC ACID VALUES FOR 69 FROSTBITE PATIENTS

Race	No. of Patients (Fasting)	Mean Hourly Urinary Ascorbic Acid mgm/100 cc.	Standard Deviation
White	29	1.47	± 1.099
Negro	37	1.41	± 1.167
Puerto Rican	3	2.20	± 2.458
Grand Mean		1.47	± 1.175

TABLE 7

RACIAL COMPARISON OF INITIAL MEAN HOURLY URINARY ASCORBIC ACID VALUES FOR 69 FROSTBITE PATIENTS

Race	No. of Cases (Fasting)	Mean Hourly Urinary Ascorbic Acid mgm/100 cc.	Standard Deviation	t	P
White Negro	29 37	1.47 1.41	± 1.099 ± 1.167	0.214	>.90
Negro Puerto Rican	37 3	1.41 2.20	± 1.167 ± 2.458	0.552	>.60
White Puerto Rican	29 3	1.47 2.20	± 1.099 ± 2.458	0.509	>.70

strated. Likewise when the 69 values of ascorbic acid in sera of the combined races and 69 values in corresponding urines were compared, no correlation was observed. The "r" value for the product-moment correlation of all the data was 0.042. These results proved that there was no correlation between fasting sera levels of vitamin C (mgm. per 100 cc.) and the amounts (mgm. per hour) eliminated in the corresponding urine during the first day of hospitalization in Osaka,

Japan.

The comparison of the daily mean level of ascorbic acid in urines of 79 frostbite patients in accordance with the number of days they subsisted on the standard diets of the Osaka Army Hospital is shown in Table 8. The largest number of tests was made on day 2 and the smallest on days 4 and 5 (range 9 to 79). The average excretion per day decreased from a mean of 1.47 mgm. ascorbic acid per hour on day 1 to 1.24 mgm. per hour on day 3, subsequently rising to 2.13 mgm. per hour on days 4 and 5, and falling to 1.49 mgm. per hour (the initial value) on days 6 and 9. The difference between the maximum and minimum mean values of ascorbic acid excreted per hour, namely, 2.13 and 1.24 mgm., respectively, was not significant.

The grand mean of 257 urine values obtained from 80 frostbite subjects during the 9-day basal period was 1.39 ($\pm$ 1.093) mgm. ascorbic acid per hour. In contrast, the mean of 45 urine analyses of ascorbic acid obtained from the 15 patients whose studies began between the second and eighth day of hospitalization and terminated between the fifth and fifteenth day before beginning the loading trials with vitamin C was 1.28 ($\pm$ 0.864) mgm. per hour. The difference between these averages was not significant ($t = 0.735$; $P > 0.5$). It was evident that alterations of the concentration of vitamin C in blood were more critical than those in urine. The urine values substantiate the conclusion that the unsupplemented hospital diet (estimated daily content of 184 mgm. of ascorbic acid) was not able to increase significantly, during the basal test period, the quantities of

TABLE 8

COMPARISON OF MEAN HOURLY URINARY ASCORBIC ACID VALUES FOR 79 PATIENTS WITH RESPECT TO NUMBER OF DAYS SUBSISTING ON ARMY HOSPITAL DIET

Days After Admission	Subjects (Fasting)	Mean Hourly Urinary Ascorbic Acid mgm/100 cc.	Standard Deviation	t	P
1 2	69 79	1.47 1.42	± 1.175 ± 0.956	0.282	>.80
1 3	69 73	1.47 1.24	± 1.175 ± 0.960	1.274	>.30
1 4-5	69 9	1.47 2.13	± 1.175 ± 2.762	0.709	>.50
1 6-9	69 12	1.47 1.49	± 1.175 ± 0.782	0.085	>.90
2 3	79 73	1.42 1.24	± 0.956 ± 0.960	1.158	>.30
2 4-5	79 9	1.42 2.13	± 0.956 ± 2.762	0.766	>.50
2 6-9	79 12	1.42 1.49	± 0.956 ± 0.782	0.321	>.80
3 4-5	73 9	1.24 2.13	± 0.960 ± 2.762	0.960	>.40
3 6-9	73 12	1.24 1.49	± 0.960 ± 0.782	1.135	>.30
4-5 6-9	9 12	2.13 1.49	± 2.762 ± 0.782	0.681	>.50

vitamin C eliminated in urine which were reported on the first day.

The distribution of 302 values of vitamin C in fasting urine collected from 95 frostbite subjects during the basal period is noted in Table 9. The urine values of ascorbic acid ranged from 0.13 to 1.9 mgm. per hour in 87% of the analyses. Such values are commonly quoted for normal adults in the literature. However, 13% of the urine data, representing 29 individuals, showed very wide variations, namely, from 2.0 to 8.85 mgm. per hour. The highest eliminations of vitamin C among Puerto

Ricans, Negroes and Whites were 5.90, 7.30 and 8.85 mgm. per hour, respectively.

TABLE 9

DISTRIBUTION OF MEAN HOURLY URINARY ASCORBIC ACID VALUES FOR 95 PATIENTS SUBSISTING 9 DAYS ON ARMY HOSPITAL DIET

Hourly Urinary Range of Ascorbic Acid mgm/100 cc.	Analyses for 43 Whites	Analyses for 47 Negroes	Analyses for 5 Puerto Ricans	Total Analyses	
	No.	No.	No.	No.	%
0.13 to 0.99	51	61	7	119	39.0
1.00 to 1.90	70	70	4	144	48.0
2.00 to 2.90	7	12	1	20	7.0
3.00 to 3.90	3	7	0	10	3.0
4.00 to 4.90	1	0	1	2	0.7
5.00 to 5.90	2	0	2	4	1.3
6.00 to 6.90	1	0	0	1	0.3
7.00 to 7.90	0	1	0	1	0.3
8.00 to 8.85	1	0	0	1	0.3
Total	136	151	15	302	100.0

2. Oral Loading Values

The loading studies comprised 496 analyses of the fasting blood and 496 determinations of the corresponding urines. Although it was planned to supply daily a 250 mgm. supplement of ascorbic acid for 25 days, the final tally showed that 31 of the 95 subjects had missed a dose for 1 to 3 days and one patient, a negro, had not taken the supplement for four consecutive days.

Since the proof of saturation with vitamin C for the majority of the patients was manifested before any of the "missed" doses occurred, the final conclusions were not materially affected by this error in management.

The alterations of the mean serum ascorbic acid levels for 95 patients after loading with 250 mgm. daily over a period of 25 days are shown in Table 10. Comparing the grand mean value of 0.60 mgm. of ascorbic acid per 100 cc. during the basal period with each mean found on subsequent days of supplementation, a significant rise was noted as early as 24 hours after the first dose. The highest mean vitamin C value in the serum, after 10 to 12 days of supplementation, was 1.22 mgm. per 100 cc. It is possible that this mean level might have been higher had there been no omission of the daily ascorbic acid supplement by certain subjects.

There appears to be an inverse linear relationship between the initial levels of vitamin C and the number of days which one had to supplement the hospital diet with the factor in order to saturate the blood with ascorbic acid (Table 11). At the time of admission to the Osaka Army Hospital 28 frostbite patients who showed relatively low serum levels of vitamin C, namely, 0.22 to 0.39 mgm. per 100 cc. averaged 5.2 days (equivalent to 1,300 mgm. of preformed ascorbic acid) before the criterion of saturation in blood was satisfied. Likewise, 56 cases consumed in 0.8 to 3.9 days between 200 and 975 mgm. of additional vitamin C (not including the amount in the diet) before saturation was attained. The 11 subjects who showed relatively high levels of serum ascorbic acid at the time of their admission to the hospital,

TABLE 10

COMPARISON OF MEAN SERUM ASCORBIC ACID LEVELS OBTAINED IN THE PRE-SATURATION PERIOD FOR 95 FROSTBITE PATIENTS WITH RESPECT TO SELECTED INTERVALS OF THE SUPPLEMENTATION PERIOD

Days of Supplementation with Vit. C	No. of Analyses	Mean Serum Ascorbic Acid mgm/100 cc.	Standard Deviation	t	P
0 (Pre-Saturation Period)	315	0.60	± 0.292	-	-
1	60	0.70	± 0.322	2.24	<.02
2	40	0.84	± 0.313	4.61	<.001
3	46	1.05	± 0.308	9.31	<.001
4-6	71	1.08	± 0.244	14.39	<.001
7-9	62	1.14	± 0.268	14.29	<.001
10-12	48	1.22	± 0.265	14.86	<.001
13-16	57	1.15	± 0.240	15.34	<.001
17-20	55	1.11	± 0.253	13.48	<.001
21-25	57	1.08	± 0.214	14.63	<.001

TABLE 11

AMOUNT OF PREFORMED ASCORBIC ACID AND TIME IN DAYS REQUIRED TO ACHIEVE SERUM SATURATION FOR 95 FROSTBITE PATIENTS

Rating with Respect to Vitamin C	No. of Cases	Percent of Cases	Range of Initial Mean Serum Ascorbic Acid levels mgm/100 cc.	Mean Days to Achieve Saturation in Serum	Total Preformed Ascorbic Acid Given per Patient (mgm)
Poor	28	29.5	under 0.39	5.2	1300
Fair	44	46.3	0.40 - 0.79	3.9	97.
Satisfactory	12	12.6	0.80 - 0.99	0.8	200
Excellent	11	11.5	over 1.00	None	None
Total	95	99.9			

namely, from 0.85 to 1.50 mgm. per 100 cc. were considered saturated with respect to this factor from the start. For these 11, the unsupplemented hospital diet alone was

sufficient for maintaining their ini' al levels of vitamin C throughout their pre-saturation period.

Saturation curves of serum and urine ascorbic acid levels for the frostbite casualty, 11 to 50 days post-injury, were made (Figure 1). Example saturation curves for first, second, third and fourth degree frostbite had relatively similar patterns (Figures 2,3,4,5). The immediate fall in the levels of ascorbic acid in serum and in urine as shown in Figure 4 following the withholding of the supplement for 3 days is noteworthy.

The alterations of the levels of ascorbic acid in the urine of 95 frostbite patients after daily loading with the factor are shown in Table 12. Comparing the grand mean value of 1.37 mgm. of ascorbic acid per hour in the urine during the basal period with each mean found on subsequent days of supplementation, a significant rise was noted 48 hours after the first dose. In comparison, significant increase in the vitamin C content in sera became manifested one day sooner (Table 10). The mean level of vitamin C in the urines beginning with the second day of loading, ranged from 2.26 to 6.16 mgm. per hour, which was equivalent to 1.5 to 4.5 times the urine values noted initially.

The highest mean excretion of ascorbic acid in the urine was 6.16 mgm. per hour. It is possible that this mean level might have been higher had there been no omission of the daily ascorbic acid supplement by certain subjects. The very high and inconstant standard deviations shown in the

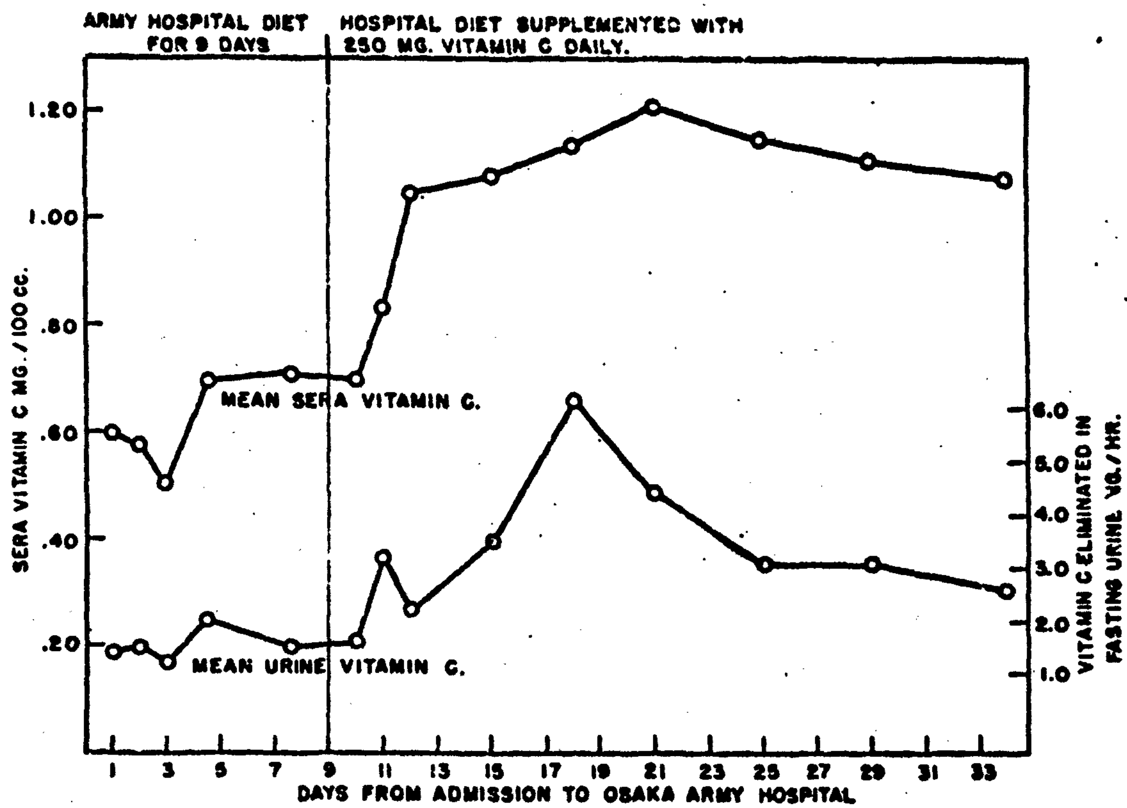


FIGURE 1. ASCORBIC ACID CURVES OF 80 FROSTBITE PATIENTS BEFORE AND AFTER LOADING WITH VITAMIN C.

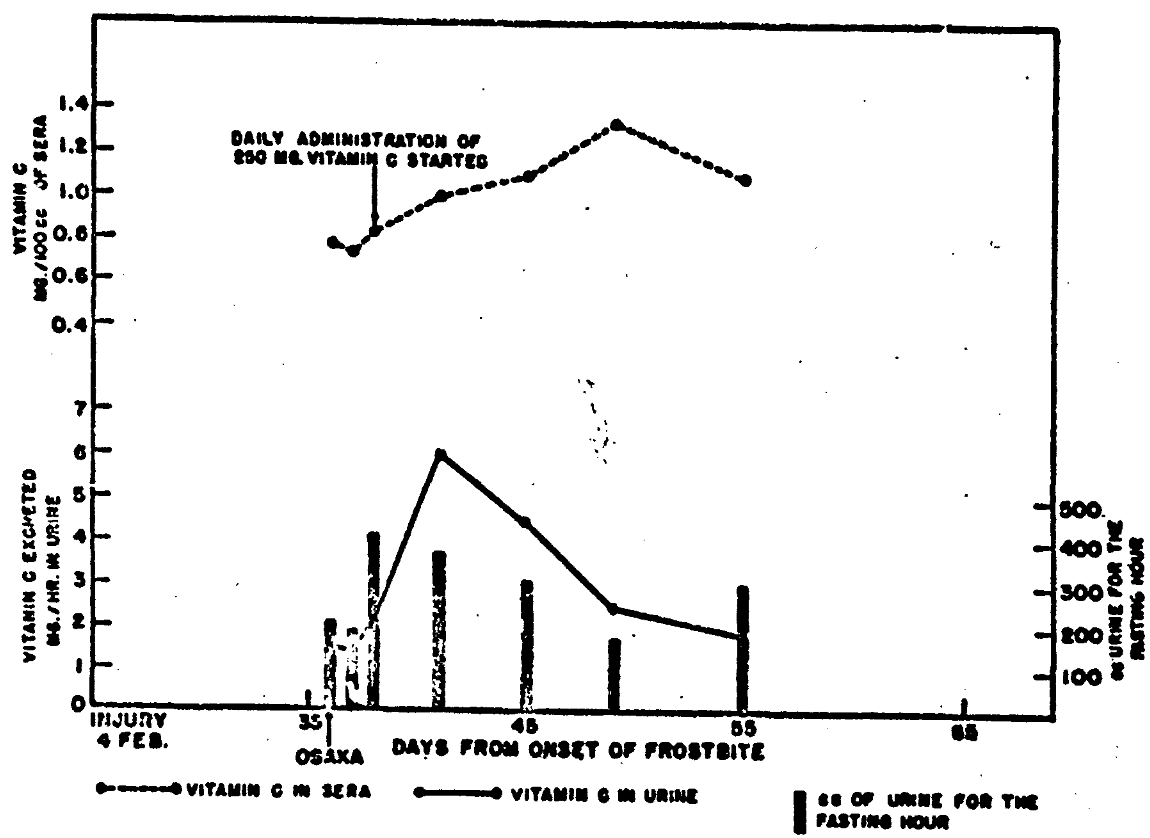


FIGURE 2. VITAMIN C LEVELS OF SERA AND URINES BEFORE AND AFTER LOADING TESTS. CASE NO.11, WHITE, 1° FROSTBITE.

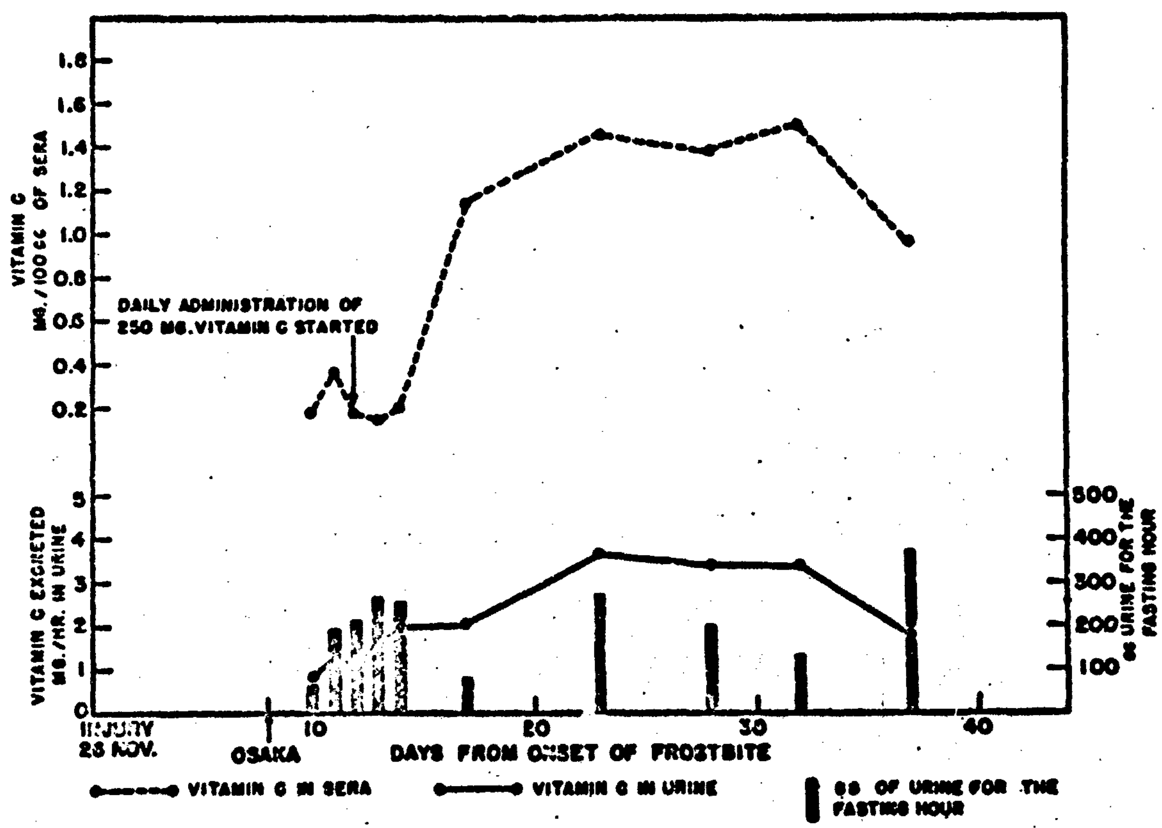


FIGURE 3. VITAMIN C LEVELS OF SERA AND URINES BEFORE AND AFTER LOADING TESTS. CASE NO. 39 WHITE 2° FROSTBITE.

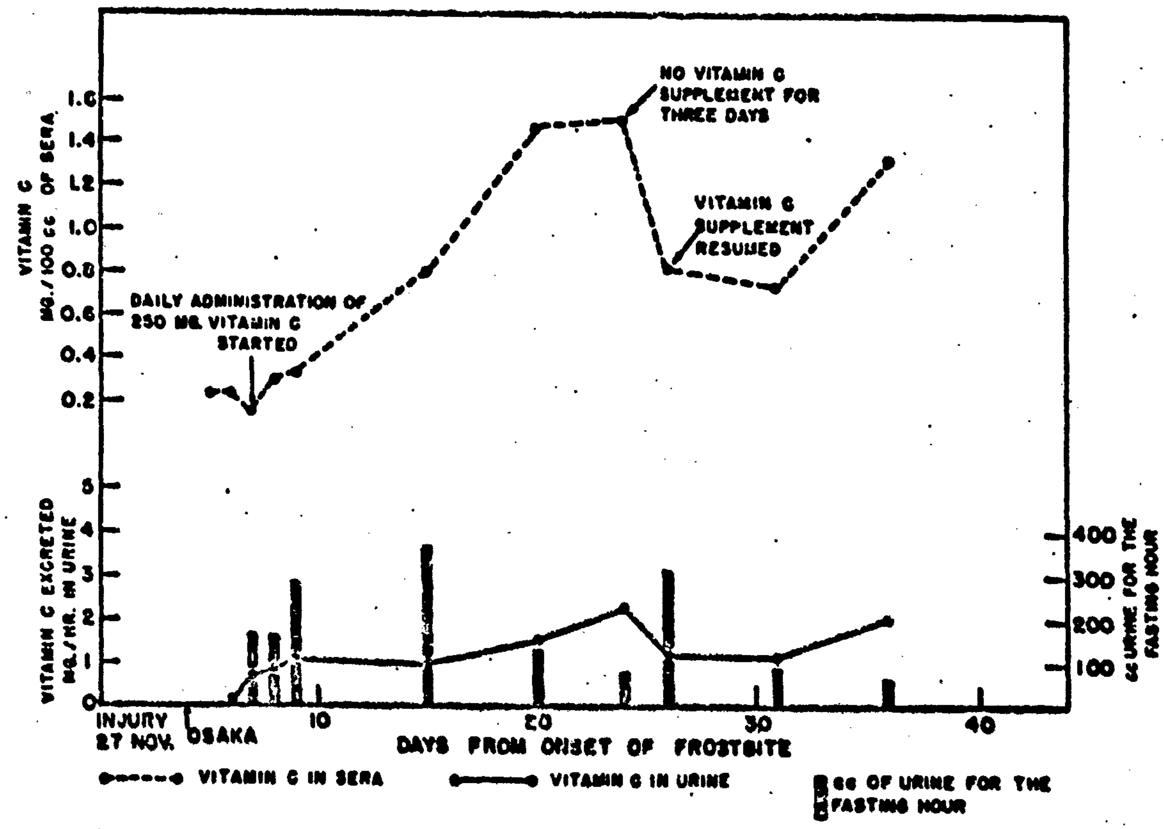


FIGURE 4. VITAMIN C LEVELS OF SERA AND URINES BEFORE AND AFTER LOADING TESTS. CASE NO. 23, WHITE, 3° FROSTBITE.

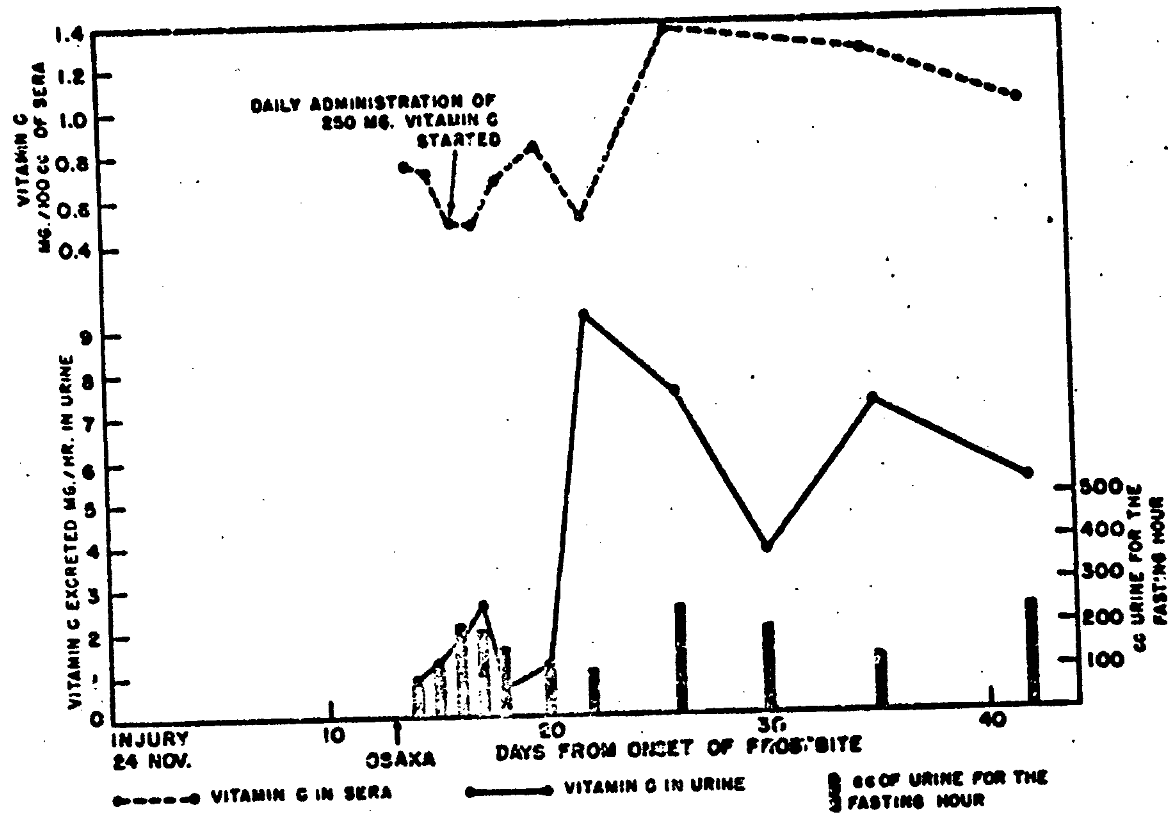


FIGURE 5. VITAMIN C LEVELS OF SERA AND URINES BEFORE AND AFTER LOADING TESTS. CASE NO. 16, NEGRO, 4° FROSTBITE.

analyses of the urines (Table 12) as compared with those of the sera (Table 10) demonstrate the marked variability in the results of the former. Such inconstant levels of ascorbic acid in urine depreciated further the value of urine determinations as a means of evaluating saturation with vitamin C under the conditions of this study.

TABLE 12

COMPARISON OF MEAN HOURLY URINARY ASCORBIC ACID VALUES OBTAINED IN THE PRE-SATURATION PERIOD FOR 95 FROSTBITE PATIENTS WITH RESPECT TO SELECTED INTERVALS OF THE SUPPLEMENTATION PERIOD

Days of Supplementation with Vit. C	No. of Analyses	Mean Hourly Urinary Ascorbic Acid mgm/100 cc.	Standard Deviation	t	P
0 (Pre-Saturation Period)	302	1.37	± 1.063	-	-
1	60	1.60	± 1.272	1.34	>.10
2	40	3.25	± 3.248	3.64	<.001
3	46	2.26	± 1.491	3.90	<.001
4-6	71	3.49	± 2.614	6.71	<.001
7-9	62	6.16	± 6.859	5.48	<.001
10-12	48	3.96	± 3.845	4.63	<.001
13-16	57	3.05	± 2.237	5.56	<.001
17-20	55	3.08	± 2.236	5.57	<.001
21-25	57	2.66	± 2.106	4.51	<.001

D. Discussion

It has been noted in the literature that saturation tests depend on the fact that renal elimination of a test dose of ascorbic acid does not occur to any significant degree in a deficient subject until his reserves have been restored (23,24). From the data of Table 10 it was seen that the mean serum vitamin C after daily supplements of the factor resulted in significantly higher values than were present during the pre-saturation period.

After the daily supplement of vitamin C, the mean elimination of the factor in the urine was not significantly higher than that noted during the pre-saturation period until 2 days had elapsed. After 2 days of such loading, however, the mean serum ascorbic acid level proved to be 0.84 mgm. per 100 cc. This value was presumed to have been the minimum level of vitamin C which had to be reached in the serum in order to attain a significant elimination of ascorbic acid in urine (hence "earliest" saturation).

It is emphasized that the meaning of the word, "saturation", in this study, is limited to the interpretation of ascorbic acid values as pertains solely to blood and urine. Until analyses of the ascorbic acid content of tissues are made on frostbite patients, one may not assume that the saturation values of the blood and urine are related to those of the tissues.

Although possible influence on the vitamin C values in blood by only a hospital diet was acknowledged, it was evident that such significant rises of vitamin C levels, by diet alone, could not have occurred in a period as brief as 24 to 48 hours. With respect to urine in particular it also was observed that no significant increase in the elimination of the factor had occurred during any of the 9 days of the basal period.

Contributing to the variable response among frostbite patients with respect to ascorbic acid may be such factors as the degree of absorption of the vitamin, its destruction in the gastrointestinal tract, the stage of wound healing, kidney function, urine pH, body size and severity of illness. The premise that

a higher utilization of vitamin C might be anticipated in these frostbite cases due to secondary infection is untenable because all subjects were free of secondary infections of their wounds. There were no significant differences in the results of 95 cases in accordance with race.

There was a strong possibility that the blood values would have been significantly raised by diet alone. The immediate aim, however, was to ensure excellent nutrition among cold injury casualties as quickly as possible. From a military point of view, the improving of the individual's well-being and possibly his rate of healing and reduction in hospital stay was paramount. Diet alone, as a rapid source of vitamin C, was proved far from satisfactory. Whether the additional vitamins affected progress in convalescence from frostbite remains a problem for future study.

The relatively enormous quantities of ascorbic acid which were ingested before saturation of the serum with this factor is noteworthy. In order to reach a concentration of 0.84 mgm. per 100 cc. twelve depleted subjects (Table 13) had ingested a total of 1,500 to 4,000 mgm. of vitamin C, omitting the amount contributed daily by diet alone. Such marked deficiency was striking inasmuch as the total vitamin C in the saturated adult has been estimated to be 3,000 to 6,000 mgm. (25,26,27). The results of the blood studies with reference to vitamin C suggested that the utilization of ascorbic acid in frostbite is high.

Most investigators are agreed that a "spill-over" of the vitamin occurs in the urine when the ascorbic acid in the blood is ap-

TABLE 13

AMOUNT OF ASCORBIC ACID AND TIME IN DAYS REQUIRED TO SATURATE THE SERUM AND TO DOUBLE THE INITIAL URINARY CONTENT FOR 12 SELECTED FROSTBITE PATIENTS

Case Number	Severity of Frostbite	Race	Initial Mean Ascorbic Acid		250 mgm. Supplements of Vitamin C daily		
			Serum mgm/100 cc.	Urine Mgm/hr/100 cc.	Days to Reach Saturation in Serum (0.84 mgm. per 100 cc.)	Days to Double Initial Vitamin C level in Urine	Total Pre-formed Vitamin C Received mgm.
20	2°	Puerto Rican	0.21	0.99	6	1	1500
26	2°	Negro	0.68	1.06	6	1	1500
1178	2°	White	0.49	4.14	13	4	3250
32	3°	White	0.32	0.61	7	1	1750
23	3°	White	0.23	0.86	9	2	2250
103	3°	Negro	0.36	1.20	16	5	4000
89	3°	Negro	0.62	1.19	7	6	1750
13	3°	Negro	0.50	0.61	9	1	2250
24	4°	Puerto Rican	0.34	0.75	6	2	1500
22	4°	Negro	0.22	1.55	7	2	1750
102	4°	Negro	0.26	1.43	14	10	3500
14	4°	White	0.42	4.10	10	8	2500

proximately 1.0 mgm. per 100 cc. The renal threshold for this vitamin has been established between 1.0 and 1.4 mgm. percent of the blood (28,29,30,31,32). It was concluded that the mean sera values 48 hours after loading with vitamin C, and thereafter, maintained threshold limits.

Although the high initial urine values of 2.0 to 8.9 mgm. of ascorbic acid per hour found among 29 subjects during the basal period cannot be explained, the following facts deserve consideration:

1) When the individual initial urine values (applied to both Whites and non-Whites) were matched against their respective sera data, no correlation between the respective values was demonstrated. Among normal persons inconsistencies between the concentration of vitamin C in blood and that in urine have been noted (11). Healthy soldiers on relatively similar nutrients, including ascorbic acid, have been found to excrete high and low quantities of the respective factors (33,34).
2) From knowledge of the disturbance of metabolites following injury, alterations such as those occurring in the catabolic and anabolic phases (35,36) could partly account for variations in the amounts of vitamin C lost by way of the urine.
3) The limitations of the titration method which may contribute to the initial high urine values for ascorbic acid are:
    a) Since the titration method is one of oxidation-

reduction a certain amount of reducing substances present in the urine irrespective of the dietary ascorbic acid will affect the readings (37). In the condition of frostbite the extent of this factor is unknown.

b) Only reduced vitamin C is determined by this titration method. About 90% of the vitamin excreted in the urine is in the reduced state the remainder being dehydroascorbic acid.

4) The conversion of reduced ascorbic acid to the dehydroascorbic acid form occurs not only in vivo but also during storage of urine samples (38,39).

5) An unknown, perhaps constant, amount of the oxidized form of vitamin C may be present in the urines of these cold injury patients.

6) The possibility of excessive water ingestion, with subsequent "washing out" of the water-soluble vitamins, is an additional factor to be considered in evaluating the urine data. The average hourly recovery of urine among the patients was 230 cc.

7) The inadequate emptying of the patient's bladder should be considered in evaluating the variations in the urine data.

8) Miscellaneous factors which might also affect the elimination of vitamin C in the urine are those pertaining to absorption of the ascorbic acid, acid-base balance, severity of injury and stresses secondary to damage (40).

IV. SURVEYS OF THE VITAMIN C CONCENTRATION OF THE BLOOD OF FROSTBITE PATIENTS AND OF NORMAL SOLDIERS

Surveys have been reported of the ascorbic acid concentration of the blood of troops on peacetime maneuvers in New England, Colorado, the Arizona desert and Canadian arctic. During World War II evaluations also were made on troops stationed in Dutch New Guinea and in Italy. A survey of the literature revealed that, except for a group of 34 soldiers afflicted with trenchfoot, ascorbic acid had not been measured among cold injury casualties (10).

This study evaluated the serum vitamin C content of a large population of soldiers before entering battle, during a combat rest period and after incurring a cold injury. This survey comprised:

Hospital admissions: 228 frostbite patients upon reaching Osaka, Japan.

Normal soldiers: a. 528 soldiers, direct from the United States, by ship, within 24 hours after debarkation in Yokohama, Japan.

b. 1,170 soldiers rotated from the Korean combat zone to Osaka, Japan. The blood samples were obtained within 5 hours after the subjects left Korea.

A. Results

1. Hospital Patients

The ascorbic acid concentration of the fasting sera of 228 frostbite casualties was obtained on their first day of admission to the Osaka Army Hospital. (Ninety subjects on whom loading tests were described in the previous section were included in this total.) All patients were hospitalized previously at the Cold Injury Center in Korea for 3 to 54 days (mean 13 days). The mean serum ascorbic acid for 228 subjects was 0.68 ($\pm$ 0.344) mgm.

per 100 cc. The mean serum ascorbic acid concentration for 122 White patients was 0.74 mgm. per 100 cc. and for 101 Negro casualties 0.61 mgm (Table 14). The difference between the means pertaining to White and Negroes was significant, but was not significant between 101 Negro and five Puerto Rican soldiers.

TABLE 14

RACIAL COMPARISONS OF INITIAL MEAN SERUM ASCORBIC ACID LEVELS FOR 228 FROSTBITE CASES

Race	No. of Cases (Fasting)	Mean Serum Ascorbic Acid mgm/100 cc.	Standard Deviation	t	P
White Negro	122 101	0.74 0.61	± 0.362 ± 0.308	9.220	<.001
White Puerto Rican	122 5	0.74 0.74	± 0.362 ± 0.672	-	-
Negro Puerto Rican	101 5	0.61 0.74	± 0.308 ± 0.672	0.431	>.70

The distribution of the serum values for the White and Negro patients is shown in Table 15, the lowest concentration being 0.08 and the highest 1.79 mgm. per 100 cc. According to the nutritional rating with respect to vitamin C, relatively poor blood stores of ascorbic acid were exhibited by 20.5% of the White and 32.7% of the Negro frostbite patients at the time of admission to the hospital in Osaka. Only 37.7% of the White subjects and 28.7% of the Negro casualties would be considered saturated with respect to vitamin C in the blood according to the criterion established in the previous section. There were too few analyses of sera of Puerto Rican soldiers to permit per-

TABLE 15

RACIAL DISTRIBUTION OF INITIAL SERUM ASCORBIC ACID VALUES FOR 223 CASES OF FROSTBITE

Rating with Respect to Vitamin C	Range of Serum Ascorbic Acid mgm/100 cc.	White		Negro	
		Number	Percent	Number	Percent
Poor	0.08 to 0.39	25	20.5	33	32.7
Fair	0.40 to 0.79	51	41.8	39	38.6
Satisfactory	0.80 to 0.99	13	10.7	14	13.9
Excellent	1.00 to 1.79	33	27.0	15	14.8
	Total	122	100.0	101	100.0

centage evaluations for this group.

All factors being equal, including time of injury and absence of complications, it has been postulated that more vitamin C may be utilized by the body in severe stress than in mild. One approach to testing this premise in frostbite was to evaluate the initial concentration of vitamin C of the blood in relation to the severity of frostbite. The ideal time for such a study would have been on the first day after injury rather than on the average of 13 days. The present classification of frostbite is based on tissue changes ranging from erythema to gangrene. This gives no indication of the total area involved which is also a factor for evaluation of alterations of metabolites essential for tissue repair. The serum ascorbic acid levels among White and Negro patients were compared according to their maximum degree of frostbite. Among White patients (Table 16) the mean serum ascorbic acid level was higher in first degree frostbite

TABLE 16

COMPARISON OF INITIAL MEAN SERUM ASCORBIC ACID LEVELS WITH RESPECT TO DEGREE OF INJURY FOR 122 WHITE FROSTBITE PATIENTS

No. of Cases (Fasting)	Degree of Frostbite	Mean Serum Ascorbic Acid mgm/100 cc.	Standard Deviation	t	P
19 64	First Second	0.78 0.79	± 0.359 ± 0.367	0.106	>.90
19 27	First Third	0.78 0.56	± 0.359 ± 0.327	2.117	<.05
19 8	First Fourth	0.78 0.74	± 0.359 ± 0.362	0.383	>.70
64 27	Second Third	0.79 0.56	± 0.367 ± 0.327	2.945	<.01
64 8	Second Fourth	0.79 0.74	± 0.367 ± 0.362	0.355	>.80
27 8	Third Fourth	0.56 0.74	± 0.327 ± 0.362	1.901	>.05

than in third degree. Also, the mean serum vitamin C level of patients with second degree frostbite was significantly higher than those with third degree. The remaining comparisons shown in Table 16 were not significant.

Among the Negro casualties (Table 17) those with first degree frostbite had a mean serum vitamin C concentration that was significantly higher than the respective means for cases with second, third or fourth degree. A comparison of the means between second and third, second and fourth or third and fourth degree cases was not significant.

In order to obtain a relationship between serum ascorbic levels, race and degree of severity of the frostbite, cases of first and second degree frostbite were designated as "mild" and those of third and fourth degree as "severe"

TABLE 17

COMPARISON OF INITIAL MEAN SERUM ASCORBIC ACID LEVELS WITH RESPECT TO DEGREE OF INJURY FOR 101 NEGRO FROSTBITE PATIENTS

No. of Cases (Fasting)	Degree of Frostbite	Mean Serum Ascorbic Acid mgm/100 cc.	Standard Deviation	t	P
11 50	First Second	0.84 0.58	± 0.373 ± 0.304	2.152	<.05
11 28	First Third	0.84 0.59	± 0.373 ± 0.303	1.978	<.05
11 11	First Fourth	0.84 0.54	± 0.373 ± 0.253	2.206	<.05
50 28	Second Third	0.58 0.59	± 0.304 ± 0.303	0.139	>.90
50 11	Second Fourth	0.58 0.61	± 0.304 ± 0.253	0.456	>.70
28 11	Third Fourth	0.59 0.54	± 0.303 ± 0.253	0.524	>.60

(Table 18). A significantly higher initial mean ascorbic acid concentration of the blood was found among 144 "mild" frostbite casualties, comprising Whites and Negroes, than in 74 cases classified as "severe". In the case of the White soldiers the difference of the means, 0.79 and 0.62 mgm. was significant. The respective differences of the means found among Negroes, namely 0.63 mgm. for "mild" frostbite and 0.58 mgm. for "severe", seemed to show the same inverse relationship to the severity of injury but were not statistically significant. In summary, there was evidence that on the thirteenth day (average) of convalescence, corresponding to the first day of hospitalization in the Army Hospital in Osaka, Japan, the mean concentration of serum vitamin C tended to be inversely related to the maximum severity of frostbite.

TABLE 18

COMPARISON OF MEAN SERUM ASCORBIC ACID LEVELS FOR "MILD" AND "SEVERE" FROSTBITE PATIENTS

Race	No. of Cases (Fasting)	Severity of Frostbite	Mean Serum Ascorbic Acid mgm/100 cc.	Standard Deviation	t	P
White & Negro Combined	144 74	Mild Severe	0.72 0.60	± 0.126 ± 0.095	2.559	<.01
White	83 35	Mild Severe	0.79 0.62	± 0.361 ± 0.339	2.429	<.01
Negro	61 39	Mild Severe	0.63 0.58	± 0.326 ± 0.278	0.822	>.50

a. Vesicular Fluids

In the course of obtaining fasting bloods 33 samples of vesicular fluid were obtained from intact blisters under aseptic technique. The age of the bullae (corresponding to the first day of hospitalization of the frostbite patients in Japan) ranged from 3 to 12 days (mean 7.5 days) post-frostbite. The ascorbic acid levels in the fluid of these vesicles were compared with those of the corresponding fasting blood sera. The fluid was cultured on withdrawal from the vesicle. The data of the ascorbic acid levels in bacteria-free fluid were compared with those of contaminated blisters.

Of the 33 samples of vesicular fluid 27 were cultured and 17 were reported free of bacteria or fungi. The data are shown in Table 19. When a product-moment correlation was made between the concentration of ascorbic acid in serum and that in blister fluid the "r" value proved significant (0.509). This indicated

TABLE 19

VESICLE FLUID CULTURE RESULTS AND ASCORBIC ACID VALUES OF CONCOMITANTLY DRAWN SAMPLES OF SERUM AND VESICLE FLUID FOR 30 FROSTBITE PATIENTS

Case No.	Serum Ascorbic Acid mgm/100 cc.	Ascorbic Acid in Vesicular Fluid mgm/100 cc.	Bacterial Culture of Vesicular Fluid
28	0.91	0.67	-
32	0.30	0.31	Negative
50	0.66	1.06	Negative
51	0.40	0.21	Negative
52	0.26	1.04	H. Staphylococci
54	0.30	0.71	Negative
55	0.53	0.78	Negative
59	0.28	0.33	Negative
62	0.61	0.73	Negative
63	0.33	0.32	Negative
64	0.72	0.76	H. Staphylocci
67	0.37	0.50	Negative
70	0.24	0.29	Negative
71	0.35	0.21	Negative
72	0.32	0.49	H. Staphylococci
73	0.23	0.60	H. Staphylococci
74	0.76	0.92	Negative
74	0.76	1.41	Non-H. Staphylococci
74	0.76	0.94	Non-H. Staphylococci
91	1.05	0.90	-
94	0.63	0.82	-
97	0.70	0.74	H. Staphylococci
99	0.33	0.32	Negative
100	0.65	0.52	H. Staph; Paracolan Bac.
101	0.66	0.21	Non-H. Staphylococci
102	0.32	0.29	Negative
102	0.32	0.26	Bac. Subtilis
106	0.97	1.31	Negative
107	0.98	1.10	Negative
109	1.14	0.16	Negative
1178	0.82	0.70	-
1481	0.24	0.74	Negative
1599	1.03	1.29	-

that the level of ascorbic acid in blister fluid varied in the same direction as the vitamin C level in blood. Omitting the samples shown to have a positive culture, the coefficient of correlation between the level of vitamin C in the sera and that in the bacteria-free blister fluids was again significant (0.874). However, when the comparison was made between the sera concentrations of ascorbic acid and those in blister fluids contaminated by bacteria the "r" value was no longer significant (0.306). This indicated that the presence of bacterial contamination may alter the relationship of ascorbic acid in vesicular fluid with that in sera.

b. Cold Hemagglutinin Titers and Vitamin C Levels

In view of the studies by the Cold Injury Team relating the titers of cold hemagglutinins in sera to the morbidity of frostbite, it was also of interest to determine whether the titers of cold hemagglutinins varied with the serum ascorbic acid levels.

A correlation between the initial serum ascorbic acid concentrations of frostbite patients and cold hemagglutinin titers was made using the values obtained from 163 identical blood samples. A negative correlation was found, namely, an "r" value of -0.015, which was not statistically significant from zero (Table 20).

Review o the data revealed that 609 blood samples drawn from normal combat soldiers in Osaka, Japan,

TABLE 20

SERUM ASCORBIC ACID LEVEL WITH CORRESPONDING COLD HEMAGGLUTININ TITERS FOR 163 FROSTBITE PATIENTS

Serum Ascorbic Acid mgm/100 cc	Hemagglutinin Titer 1:2	1:4	1:8	1:16	1:32	1:64	1:128	1:256	No. of Cases
0.0 - 0.09			1						1
0.1 - 0.19			1						1
0.2 - 0.29		1	1	3	5	3	1		14
0.3 - 0.39			4	2	4	6	2		18
0.4 - 0.49		2	3	4	2	1	1		13
0.5 - 0.59			8	4	7	2	1		22
0.6 - 0.69		1	4	5	4	2	1		17
0.7 - 0.79		2	3	5	4	5	1	1	21
0.8 - 0.89		1		5	5	2		1	14
0.9 - 0.99		1	3	3	2	2	1		12
1.0 - 1.09	1	1	3		4	2			11
1.1 - 1.19		1	1	4		1			7
1.2 - 1.29						3			3
1.3 - 1.39			3			1		2	6
1.4 - 1.49			1	2					3
Total	1	10	36	37	37	30	8	4	163

were used both for the vitamin C determinations and for the estimation of the cold hemagglutinin titers. Only 5 hours had elapsed since these subjects had left their lines of combat in Korea. The "r" value (-0.031) of the product-moment analysis correlating the concentrations of serum vitamin C with the cold hemagglutinin titers was not significant (Table 21).

2. Normal

a. Troops from the United States en route to Combat

At Camp Drake, Japan, between 1 and 8 February 1952 blood samples were obtained from 528 normal soldiers.

TABLE 21

SERUM ASCORBIC ACID LEVEL WITH CORRESPONDING COLD HEMAGGLUTININ TITERS FOR 609 NORMAL COMBAT SOLDIERS

Serum Ascorbic Acid mgm/100 cc.	Hemagglutinin Titer											No. of Cases
	Neg.	1:2	1:4	1:8	1:16	1:32	1:64	1:128	1:256	1:512	1:1024	
0.1 - 0.19			10	8	5	2	1					26
0.2 - 0.29	1	9	36	30	37	19	19	1	1			153
0.3 - 0.39	2	14	22	41	21	20	6	5			1	132
0.4 - 0.49	1	4	25	21	13	12	12	1				89
0.5 - 0.59		3	8	15	12	12	3	3	1			57
0.6 - 0.69		3	6	9	16	6	4	3		1		48
0.7 - 0.79		3	6	7	5	5	2	2	1			31
0.8 - 0.89		1	6	7	6	4	1	1				26
0.9 - 0.99	1	1	3	6	5	1	1					18
1.0 - 1.09		1	5	2	3	1						12
1.1 - 1.19			2	2	2							6
1.2 - 1.29		1	3	2	1							7
1.3 - 1.39			1	1								2
1.4 - 1.49			1		1							2
Total	5	40	134	151	127	82	49	16	3	1	1	609

These subjects arrived in Yokohama from the United States via ship 24 hours prior to testing. The mean fasting serum ascorbic acid level for this group was 0.42 $\pm$ 0.247 mgm. per 100 cc. The racial distribution of these troops was: Whites, 402; Negroes, 30; Puerto Ricans, 78 and miscellaneous, 18 (i.e. 11 Latin Americans, 6 Orientals and 1 Indian).

The mean of 0.42 mgm. ascorbic acid per 100 cc. of serum exhibited by 402 White soldiers was significantly lower than that of 0.56 mgm. shown by 30 Negro soldiers (Table 22). There was no significant difference between the mean serum concentrations of vitamin C found in Whites and Puerto Ricans, but a significant difference existed between the Puerto Ricans and Negroes. The mean value among 30 Negroes, namely, 0.56 mgm. of ascorbic acid per 100 cc. of serum, was significantly higher than that of 0.36 mgm. shown by 18 soldiers of miscellaneous lineage (Latin Americans, Orientals, Indians and Filipinos).

The results of the determinations for Whites, Negroes and Puerto Ricans are presented in Figure 6. The relatively high percentage of troops which showed low levels of ascorbic acid in the blood, namely, 0.4 mgm. per 100 cc. or less, was particularly noteworthy. Of the three races the Puerto Ricans had the highest proportion of low values in the sera.

TABLE 22

RACIAL COMPARISONS OF MEAN SERUM ASCORBIC ACID LEVELS FOR NORMAL TROOP REPLACEMENTS

Race	No. of Cases (Fasting)	Mean Serum Ascorbic Acid mgm/100 cc.	Standard Deviation	t	P
White Negro	402 30	0.42 0.56	± 0.252 ± 0.310	2.414	<.01
White Puerto Rican	402 78	0.42 0.39	± 0.252 ± 0.167	1.322	>.20
White Misc. Lineage	402 18	0.42 0.36	± 0.252 ± 0.233	1.066	>.30
Negro Puerto Rican	30 78	0.56 0.39	± 0.310 ± 0.167	2.848	<.01
Negro Misc. Lineage	30 18	0.56 0.36	± 0.310 ± 0.233	2.535	<.02
Puerto Rican Misc. Lineage	78 18	0.39 0.36	± 0.167 ± 0.233	0.517	>.70

b. Healthy Soldiers on Rotation from the Combat Lines of Korea

Between January and April 1952 serum ascorbic acid levels were determined for 1,170 soldiers who had been rotated from combat in Korea to the Rest and Recreation Center (called R & R) located in Osaka, Japan. These troops arrived by plane, usually in the late afternoon. In the majority of instances no food was served during the trip by air so that six or more hours had elapsed since breakfast in Korea and prior to their first meal in the Osaka Center. Within 10 minutes after the meal a venous blood sample was drawn and immediately processed for vitamin C. The mean for 1,170 soldiers was 0.48 mgm (± 0.270) per 100 cc. of serum with a distribution as shown in Table 23. The 25 soldiers referred to as miscellaneous lineage in Table 23 com-

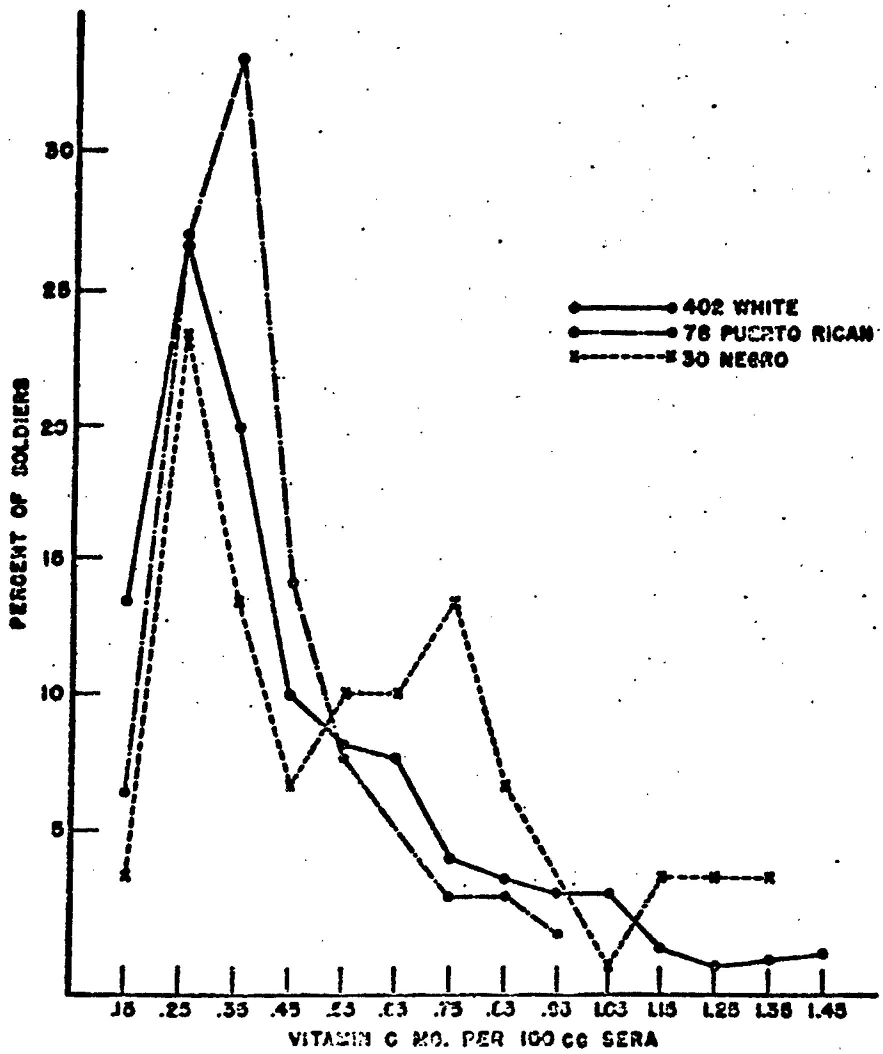


FIGURE 6. DISTRIBUTION OF ASCORBIC ACID LEVELS IN SERA OF 510 REPLACEMENT TROOPS UPON ARRIVAL IN JAPAN 2-8 FEBRUARY 52.

TABLE 23

RACIAL COMPARISONS OF MEAN SERUM ASCORBIC ACID LEVELS FOR 1170 UNINJURED COMBAT SOLDIERS

Race	No. of Cases (Fasting)	Mean Serum Ascorbic Acid mgm/100 cc.	Standard Deviation	t	P
White Negro	1018 117	0.47 0.51	± 0.269 ± 0.274	1.498	>.20
White Puerto Rican	1018 10	0.47 0.55	± 0.269 ± 0.252	0.998	>.40
White Misc. Lineage	1018 25	0.47 0.44	± 0.269 ± 0.288	0.516	>.70
Negro Puerto Rican	117 10	0.51 0.55	± 0.274 ± 0.252	0.478	>.40
Negro Misc. Lineage	117 25	0.51 0.44	± 0.274 ± 0.288	1.146	>.70
Puerto Rican Misc. Lineage	10 25	0.55 0.44	± 0.252 ± 0.288	1.119	>.30

prised 14 Latin Americans, 6 Orientals, 3 Indians, 1 Filipino and 1 Hawaiian.

The results of the determinations on White and Negro subjects are presented in Figure 7. These curves were similar to those representing data of the 528 replacement troops from the United States (Figure 6). Figure 7 also depicts the variations of the average concentration of serum vitamin C during the months January through April 1952. Each dot represents serum values from 20 to 80 men with an average of 40. It is apparent that there was little deviation from the mean of 0.48 mgm. from month to month. There were no significant differences between the means of the serum vitamin C levels with respect to race in this group of 1,170 soldiers direct from combat activity (Table 23).

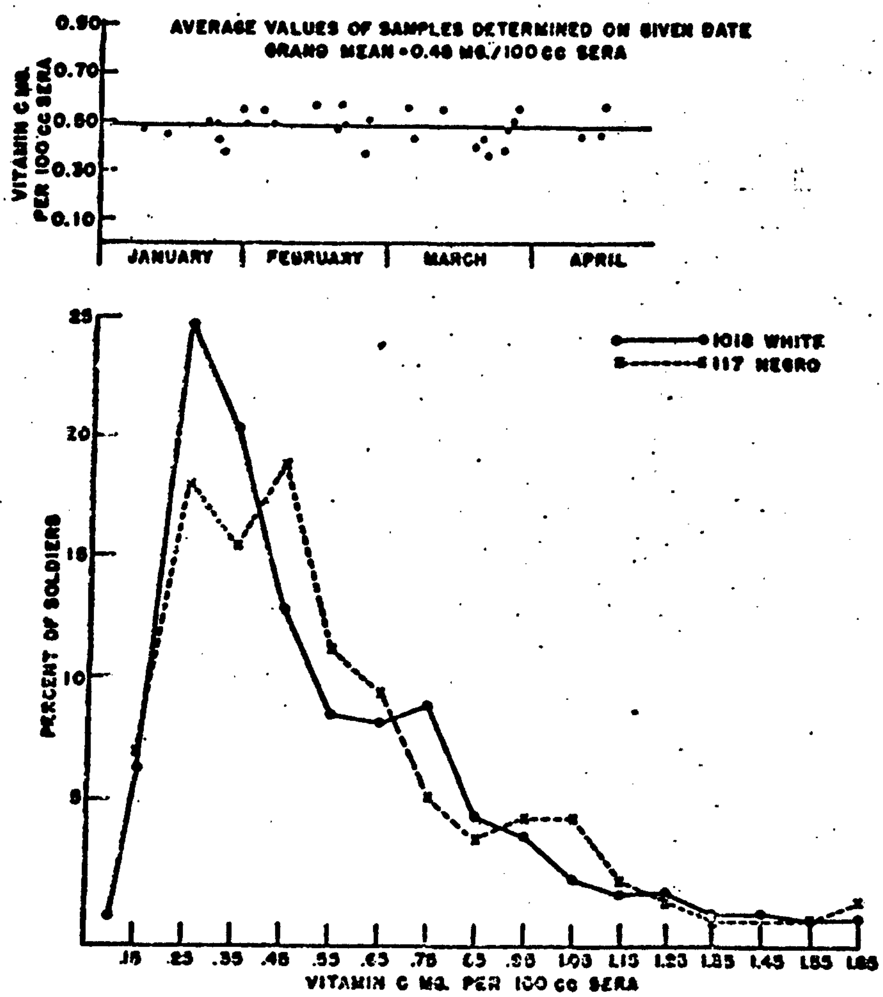


FIGURE 7. DISTRIBUTION OF ASCORBIC ACID LEVELS IN SERA OF 1135 SOLDIERS DIRECTLY AFTER LEAVING COMBAT LINES IN KOREA, JAN.-APRIL 1952.

The mean concentration of serum ascorbic acid for troops arranged in accordance with the military components of the Eighth Army in Korea is shown in Table 24. With the exception of the 24th Division which was represented by only two soldiers (these values omitted) the units were each represented by 95 to 221 soldiers. The mean serum ascorbic acid values for the men of the respective divisions ranged from 0.44 to 0.54 mgm. per 100 cc. From a nutritional rating with respect to vitamin C the averages were considered fair and of relatively equal value. When the military components of the Eighth Army were arranged in accordance with their positions in battle (Table 25) the respective means were essentially constant, namely, 0.44 to 0.50 mgm. of ascorbic acid per 100 cc. of serum. No differences in rating from a nutritional viewpoint were again evident. Statistically, however, the low vitamin C values shown by the rear troops of the Eighth Army, namely, 0.44 mgm. per 100 cc. of serum, proved significantly lower than that of any of the remaining troops (Table 26).

It already has been shown (Table 23) that there was no significant difference between the mean concentration of 0.47 mgm. ascorbic acid per 100 cc. shown by the 1,018 White combat troops and that of 0.51 mgm. by the 117 Negro troops. There were no significant differences in the mean levels of serum vitamin C

TABLE 24

MEAN SERUM ASCORBIC ACID VALUES FOR UNINJURED COMBAT PERSONNEL ASSIGNED TO INFANTRY DIVISIONS

Division	No. of Soldiers Tested	Mean Serum Ascorbic Acid mg/100 cc.	Standard Deviation
2nd	161	0.54	± 0.324
3rd	188	0.47	± 0.276
7th	113	0.48	± 0.242
25th	190	0.47	± 0.263
40th	136	0.53	± 0.260
45th	95	0.47	± 0.224
Misc. Rear Troops of Eighth Army	221	0.44	± 0.251

TABLE 25

MEAN SERUM ASCORBIC ACID VALUES FOR UNINJURED COMBAT SOLDIERS IN RELATION TO THEIR COMBAT ECHELON

Combat Echelon	No. of Soldiers Tested	Mean Serum Ascorbic Acid mg/100 cc.	Standard Deviation
Misc. Rear Troops of Eighth Army	221	0.44	± 0.251
Divisional Troops	356	0.50	± 0.287
Regimental Troops	335	0.49	± 0.266
Battalion Troops	183	0.49	± 0.252

for Negro soldiers in accordance with the military unit to which they were assigned (Table 27). In the case of White troops certain significant differences between the mean concentrations of serum ascorbic acid in accordance with military component were found (Table 28). For example, the White

TABLE 26

COMPARISON OF MEAN SERUM ASCORBIC ACID LEVELS FOR UNINJURED SOLDIERS WITH RESPECT TO THEIR COMBAT ECHELON

Military Support	No. of Soldiers	Mean Serum Ascorbic Acid mgm/100 cc.	Standard Deviation	t	P
Misc. Rear Troops Divisional Troops	221 356	0.44 0.50	± 0.251 ± 0.287	2.730	<.01
Misc. Rear Troops Regimental Troops	221 335	0.44 0.49	± 0.251 ± 0.266	2.466	<.02
Misc. Rear Troops Battalion Troops	221 188	0.44 0.49	± 0.251 ± 0.252	2.040	<.02
Divisional Troops Regimental Troops	356 335	0.50 0.49	± 0.287 ± 0.266	0.474	>.70
Divisional Troops Battalion Troops	356 188	0.50 0.49	± 0.287 ± 0.252	0.420	>.70
Regimental Troops Battalion Troops	335 188	0.49 0.49	± 0.266 ± 0.252	-	-

soldiers in the 2nd and 40th Divisions showed mean sera levels of 0.53 and 0.52 mgm. per 100 cc., respectively, which were significantly higher than the average of 0.45 and 0.42 mgm. shown by White soldiers of the 3rd Division and a group labelled "miscellaneous rear troops", respectively. Since the eating habits of these individuals were not ascertained the possible influence of this factor on the data cannot be estimated. In spite of mathematically significant differences in the respective

TABLE 27

COMPARISON OF MEAN SERUM ASCORBIC ACID VALUES FOR NEGRO SOLDIERS IN ACCORDANCE TO THEIR COMBAT ECHELON

Military Unit	No. of Negro Soldiers	Mean Serum Ascorbic Acid mgm/100 cc.	Standard Deviation	t	P
2nd Div.	5	0.53	± 0.348	0.117	>.90
7th Div.	10	0.55	± 0.222		
40th Div.	8	0.53	± 0.290	0.201	>.90
7th Div.	10	0.55	± 0.222		
3rd Div.	36	0.50	± 0.336	0.163	>.90
2nd Div.	5	0.53	± 0.348		
25th Div.	10	0.55	± 0.310	0.109	>.90
2nd Div.	5	0.53	± 0.348		
40th Div.	8	0.53	± 0.290	-	-
2nd Div.	5	0.53	± 0.348		
2nd Div.	5	0.53	± 0.348	0.198	>.90
Misc. Rear Troops	33	0.50	± 0.246		
25th Div.	10	0.55	± 0.310	0.416	>.70
3rd Div.	36	0.50	± 0.336		
40th Div.	8	0.53	± 0.290	0.188	>.90
3rd Div.	36	0.50	± 0.336		
3rd Div.	36	0.50	± 0.336	-	-
Misc. Rear Troops	33	0.50	± 0.246		
40th Div.	8	0.53	± 0.290	0.176	>.90
25th Div.	10	0.55	± 0.310		
25th Div.	10	0.55	± 0.290	0.486	>.70
Misc. Rear Troops	33	0.50	± 0.246		
40th Div.	8	0.53	± 0.290	0.243	>.90
Misc. Rear Troops	33	0.50	± 0.246		

mean concentrations of ascorbic acid, shown by the soldiers in Table 28, it is emphasized that the degree of the respective differences was not of such magnitude that one necessarily could rate the men of one division nutritionally better than those of any other division with regard to vitamin C. Until a more accurate definition of the normal level of

TABLE 28

COMPARISON OF MEAN SERUM ASCORBIC ACID VALUES FOR WHITE SOLDIERS IN ACCORDANCE TO THEIR COMBAT ECHELON

Military Unit	No. of White Soldiers	Mean Serum Ascorbic Acid mgm/100 cc.	Standard Deviation	t	P
2nd Div. Misc. Rear Troops	119 187	0.53 0.42	± 0.292 ± 0.250	3.261	<.001
2nd Div. 3rd Div.	119 138	0.53 0.45	± 0.292 ± 0.264	2.149	<.05
2nd Div. 7th Div.	119 93	0.53 0.46	± 0.292 ± 0.238	1.846	>.10
2nd Div. 25th Div.	119 171	0.53 0.47	± 0.292 ± 0.264	1.672	>.10
2nd Div. 40th Div.	119 127	0.53 0.52	± 0.292 ± 0.261	0.113	>.90
2nd Div. 45th Div.	119 93	0.53 0.47	± 0.292 ± 0.224	1.582	>.20
25th Div. 40th Div.	171 127	0.47 0.52	± 0.264 ± 0.261	1.688	>.10
40th Div. Misc. Rear Troops	127 187	0.52 0.42	± 0.261 ± 0.250	3.424	<.001
3rd Div. 40th Div.	138 127	0.45 0.52	± 0.264 ± 0.261	2.191	<.05
7th Div. 40th Div.	93 127	0.46 0.52	± 0.238 ± 0.261	1.858	>.10
45th Div. 40th Div.	93 127	0.47 0.52	± 0.224 ± 0.261	1.581	>.20
45th Div. Misc. Rear Troops	93 187	0.47 0.42	± 0.224 ± 0.250	1.661	>.10
3rd Div. 45th Div.	138 93	0.45 0.47	± 0.264 ± 0.224	0.586	>.60
7th Div. 45th Div.	93 93	0.46 0.47	± 0.238 ± 0.224	0.325	>.80
3rd Div. Misc. Rear Troops	138 187	0.45 0.42	± 0.264 ± 0.250	1.035	>.30
7th Div. Misc. Rear Troops	93 187	0.46 0.42	± 0.238 ± 0.250	1.238	>.30
25th Div. Misc. Rear Troops	171 187	0.47 0.42	± 0.264 ± 0.250	1.802	>.10
7th Div. 3rd Div.	93 138	0.46 0.45	± 0.238 ± 0.264	0.239	>.90
25th Div. 3rd Div.	171 138	0.47 0.45	± 0.264 ± 0.264	0.627	>.60
7th Div. 25th Div.	93 171	0.46 0.47	± 0.238 ± 0.264	0.345	>.80

vitamin C in the blood is established, it was concluded that the 1,170 combat soldiers were all of the same nutritional status with respect to vitamin C. From a nutritional rating standpoint the mean blood levels were considered borderline between poor and fair.

The mean serum ascorbic acid levels for 510 replacement troops and 1,135 combat soldiers are shown in Table 29. The percent distribution for poor, fair, satisfactory and excellent ratings with respect to vitamin C among combat soldiers agreed closely with the respective amounts noted among the replacement troops. Among combat soldiers the serum levels of ascorbic acid, namely, 0.07 to 0.39 mgm. per 100 cc. were found in 51.6% of the Whites and 40.2% of the Negroes (Table 29). Based on the minimum value of 0.84 mgm. per 100 cc. of serum (discussed in the previous section) it was concluded that only 13.2% of the Whites and 15.4% of the Negroes were saturated with respect to vitamin C in the serum.

Among the replacement troops 59.9% of the Whites, 40.0% of the Negroes and 66.7% of the Puerto Ricans showed serum ascorbic acid levels of 0.39 mgm. or less per 100 cc. Only 10.2% of the Whites, 20.0% of the Negroes and 3.8% of the Puerto Ricans were considered saturated with respect to vitamin C in the serum. From a nutritional viewpoint with regard

TABLE 29

RACIAL DISTRIBUTION OF SERUM ASCORBIC ACID LEVELS
FOR 510 REPLACEMENT AND 1135 COMBAT SOLDIERS

Rating with Respect to Vitamin C	Range of Serum Ascorbic Acid mgm/100 cc.	Replacement Troops direct from the United States upon arriving in Tokyo						Combat Soldiers direct from Korea			
		White		Negro		Puerto Ricans		White		Negro	
		No.	%	No.	%	No.	%	No.	%	No.	%
Poor	0.07 to 0.39	241	59.9	12	40.0	52	66.7	525	51.6	47	40.2
Fair	0.40 to 0.79	120	29.9	12	40.0	23	29.5	359	35.2	52	44.4
Satisfactory	0.80 to 0.99	24	6.0	3	10.0	3	3.8	80	7.9	9	7.7
Excellent	1.00 to 1.67	17	4.2	3	10.0	0	0.0	54	5.3	9	7.7
	Total	402	100.0	30	100.0	78	100.0	1018	100.0	117	100.0

to ascorbic acid, over 80% of the 528 replacement troops and over 87% of the 1,035 combat soldiers showed poor to fair blood levels. Despite these low levels of ascorbic acid the soldiers appeared in excellent health.

The mean levels of serum ascorbic acid for soldiers en route to battle, during a combat rest period and after incurring frostbite were 0.42, 0.48 and 0.68 mgm. per 100 cc., respectively (Table 30).

The mean serum ascorbic acid content for healthy White troops was significantly higher during combat than the levels manifested by soldiers arriving in the Far East. Neither the increase in the mean serum ascorbic acid among healthy Puerto Ricans nor the decrease among healthy Negroes was statistically significant (Table 31).

TABLE 30

COMPARISON OF MEAN SERUM ASCORBIC ACID VALUES AMONG REPLACEMENT TROOPS, COMBAT SOLDIERS AND FROSTBITE CASES

No. of Subjects	Situation	Mean Serum Ascorbic Acid mgm/100 cc.	Standard Deviation	t	P
223 528	Frostbite Patients Replacement Troops	0.68 0.42	± 0.344 ± 0.247	10.232	<.001
223 1170	Frostbite Patients Combat Soldiers	0.68 0.48	± 0.344 ± 0.270	8.217	<.001
528 1170	Replacement Troops Combat Soldiers	0.42 0.48	± 0.247 ± 0.270	4.501	<.001

TABLE 31

RACIAL COMPARISONS OF MEAN SERUM ASCORBIC ACID VALUES AMONG REPLACEMENT TROOPS, COMBAT SOLDIERS AND FROSTBITE PATIENTS

Group	Race	No. of Cases	Mean Serum Ascorbic Acid mgm/100 cc.	Standard Deviation	t	P
Replacement Troops	White	402	0.42	± 0.252	3.311	<.001
Combat Soldiers	White	1018	0.47	± 0.269		
Replacement Troops	White	402	0.42	± 0.252	9.117	<.001
Patients	White	122	0.74	± 0.362		
Combat Soldiers	White	1018	0.47	± 0.269	7.988	<.001
Patients	White	122	0.74	± 0.362		
Replacement Troops	Negro	30	0.56	± 0.310	0.807	>.50
Combat Soldiers	Negro	117	0.51	± 0.274		
Replacement Troops	Negro	30	0.56	± 0.310	0.753	>.50
Patients	Negro	101	0.61	± 0.303		
Combat Soldiers	Negro	117	0.51	± 0.274	2.513	<.01
Patients	Negro	101	0.61	± 0.303		
Replacement Troops	Puerto Rican	10	0.55	± 0.252	1.954	>.10
Combat Soldiers	Puerto Rican	78	0.39	± 0.167		
Replacement Troops	Puerto Rican	78	0.39	± 0.167	1.162	>.30
Patients	Puerto Rican	5	0.74	± 0.672		
Combat Soldiers	Puerto Rican	10	0.55	± 0.252	0.611	>.60
Patients	Puerto Rican	5	0.74	± 0.672		

B. Discussion

It was of interest to compare the data of frostbite patients in the study with those of soldiers admitted to army hospitals during World War II. World War II troops subsisted on packaged rations prior to hospitalization, although studies relative

to cold injuries, per se, were not made. During the Italian Campaign, in the winter of 1944, Carney (10) reported studies on 100 random hospital admissions (32 medical and 68 wounded, half of the latter having had trenchfoot). The plasma concentration of vitamin C for 70% of the patients ranged from 0.2 to 0.5 mgm. The individual values of vitamin C ranged from 0.10 to 2.35 mgm. per 100 cc. of plasma.

A larger survey of hospitalized soldiers (disease and injuries not listed) was made by Golden and Schechter in Dutch New Guinea (9). They reported that on standard unsupplemented diets 59% of 171 patients showed an average of less than 0.30 mgm. of ascorbic acid per 100 cc. of plasma, while 42 subjects whose diet was supplemented daily with 37 mgm. of vitamin C yielded a mean of 0.57 mgm. ascorbic acid per 100 cc. plasma. These low values could not be explained. The hospital food was rated equal to, and perhaps better than, that issued in the company messes. Variability in the standards of mess management and in the discriminatory tastes of the soldiers with reference to the fruit juices and synthetic lemon powder, major source of vitamin C, were considered. The possibility of higher demands for vitamin C in the stresses of the tropics, and particularly following onset of illness, was not considered.

The relatively low blood values for ascorbic acid of hospitalized soldiers agree essentially with those reported among hospitalized civilians in the United States, in spite of the fact that deficiencies in the latter reflect their economic status and food customs in addition to their ills (Table 32).

TABLE 32

BLOOD ASCORBIC ACID VALUES FOR HOSPITALIZED CIVILIANS

Adults	Cases	Location	Subjects with a Mean Serum or Plasma Ascorbic Acid Level of 0.5 mgm. or less per 100 cc.	Source*
20	Gastro-Intestinal	Boston, Massachusetts	85% at 0.4 mgm. or less	48
55	Rheumatoid Arthritis	San Francisco, California	75% at 0.3 mgm. or less	49
100	Medical	Chicago, Illinois	38% at 0.4 mgm. or less	50
183	Surgical	Boston, Massachusetts	66% at 0.5 mgm. or less	51
70	Surgical	San Francisco, California	44% at 0.3 mgm. or less	52
29	Bronchial Asthma	New Orleans, Louisiana	65% at 0.4 mgm. or less	53
157	Psychiatric	New York, New York	42% at 0.4 mgm. or less	14
321	Medical	New Found-land	50% at 0.3 mgm. or less	54
350	Medical	Birmingham, Alabama	61% at 0.4 mgm. or less	55
21	Coronary Occlusion	Canada	90% at 0.25 mgm. or less	24
380	Psychiatric	Elgin, Illinois	50% at 0.4 mgm. or less	56

* Numbers refer to citations in Bibliography

These data were from patients usually older than those of the military and of both sexes.

Although individual values of ascorbic acid in blood vary widely, mean values of a population of one sex under comparable conditions and in equilibrium with their diets have significance (41,42,43). Low values, in particular, noted under such conditions merit corrective measures. One could attempt an explanation for the changes in the serum vitamin C levels of soldiers from the time they left ship in Japan until ultimately hospitalized as war casualties. In common, all troops were subjected several weeks or months to similar foods in army messes in the United States before leaving for Korea. The interpretations remain conjectural since the same soldiers were not followed from the time of debarkation in Japan until participation in battle, or from the time of battle until their hospitalization with frostbite.

The finding of a relatively low mean level of serum vitamin C for 528 normal soldiers upon debarkation was difficult to explain. It was assumed the food on shipboard was adequate. There were no records of the type of foods served or the eating habits of these men. The nutrition with respect to vitamin C before embarkation was assumed to have been equalized during the weeks or months which the average soldier subsisted on food in army messes. One could not estimate whether possible effects pertaining to the ocean voyage itself (e.g. seasickness, vomiting, psychological stresses concomitant with the landing on foreign soil, etc.) might have contributed to the

findings with respect to serum ascorbic acid.

It was concluded that the recent shipboard diets maintained levels of serum ascorbic acid in these replacement troops which could be rated only slightly better than poor. The question is raised, therefore, whether such low levels with respect to vitamin C in the blood are within the "margin of safety" for pre-combat soldiers.

The mean serum ascorbic acid level for the frostbite convalescent in the Osaka Army Hospital was higher than the average value exhibited by soldiers en route to, or after participation in, battle. In the case of the White and Negro soldiers, but not in the case of the Puerto Ricans, the difference between the serum vitamin C values for hospitalized casualties and active combat soldiers was statistically significant. The nutritional rating with respect to vitamin C also was improved appreciably, although the blood levels of the hospitalized subjects were still below the amount which characterize saturation of the blood. According to values cited by the National Research Council (44, 45) the mean values observed on the thirteenth day of convalescence for the Negro, Puerto Rican and White frostbite patients, namely, 0.61, 0.74 and 0.74 mgm. per 100 cc. of serum, were "low normal". The availability of warm palatable foods rich in vitamin C during evacuation largely accounted for the differences between the results for normal soldiers and frostbite casualties. The fact that the mean serum ascorbic acid level shown by the hospitalized White patients

was significantly higher than that shown by Negro frostbite patients was not explainable. Every condition, including diet, was essentially equalized. Although possible racial differences in the acceptance of certain foods were offered as a partial explanation, this was not the case in a survey of the food habits of 51 men 24 hours prior to frostbite. In the first portion of this report, the results of the survey of food acceptance by 26 Negro and 25 White soldiers (who had occasion to eat at least one meal of combat ration) demonstrated no significant difference in their respective acceptance of coffee powder, jam and cocoa powder. This lack of discrimination in taste for these items under combat conditions may not be the rule for Negroes and Whites with respect to their acceptance of other vitamin C-rich foods, particularly when confined in a hospital. Factors other than food preference are also worthy of consideration in attempting to explain the difference in the mean levels of ascorbic acid in the blood, for example:

1) Differences in vitamin C intake just prior to these tests.
2) Possible inherent physiological differences between the White and Negro races.
3) Individual physiological differences, e.g. acid-base balance, absorptive capacity for the vitamin and the like.
4) The limitations of the titration method for determining ascorbic acid in metaphosphoric acid

filtrates from serum.

5) Difference in the ascorbic acid level of the blood in accordance with severity of illness have been cited earlier in this report. Decreases and increases in the plasma vitamin C levels have been noted following fractures and burns in accordance with duration of the catabolic or anabolic phase of injury (46,47). It remains to be proved whether such changes are manifested in damage due to frostbite.

6) It is conjectured that the vitamin C concentrations of the blood might have been altered in accordance with stress.

Under present Army Regulation (AR 40-250) the daily stipulated requirement for vitamin C is 50 mgm. It was estimated that one day's food, eaten in full, as obtained from the mess or from packaged rations i.e. one Individual Combat Ration, one fifth of the Small Detachment 5-in-1 Ration, three Individual Assault Rations (IA-2) or three Frigid Trail Rations (TF-2) would supply approximately 100 mgm. of ascorbic acid per day per man. It is to be recalled that the Osaka Army Hospital diet was calculated to provide nearly 184 mgm. of vitamin C daily omitting possible losses of the factor resulting from waste and the processing of food.

Notwithstanding that the requirement of vitamin C, as stipulated by regulation, was met, the ascorbic acid intake by the soldier was of such low order that his serum was found to be

far from saturated with respect to vitamin C. To account for this in part, discriminatory taste with respect to vitamin C containing foods and losses of the factor either through waste or as a result of processing the food were considered.

The results of the 1951-52 vitamin C survey on 1,698 men in Japan, comprising "healthy" combat and pre-combat soldiers, indicated that 50% of the individuals exhibited levels of the order of 0.5 mgm. vitamin C per 100 cc. of serum. Because of potential wounds, infections and many stresses to which a soldier is exposed, a serum level of approximately 0.80 mgm. ascorbic acid per 100 cc. is suggested as a good "margin of safety". A level of the order of 0.80 mgm. per 100 cc. is used by many investigators in defining a "satisfactory" blood level of vitamin C for the normal adult. The actual value, 0.84 mgm. was found to mark the beginning of saturation of serum of convalescing frostbite patients. Since it is not known whether the supplying of additional vitamin C for an indefinite period to maintain blood concentrations of the factor at saturation levels is physiologically sound, the administration of vitamin C smaller than the daily 250 mgm. supplement (provided in this study) might ensure blood levels which might be considered more nearly "satisfactory".

Assuming a linear relationship between intake increments and serum level elevations of vitamin C, to increase the levels in healthy soldiers from an average of 0.5 mgm. to 0.84 mgm. approximately a 70% increase in the vitamin C intake over that

which prevailed during this survey would be necessary (provided that factors of food acceptance and vitamin C losses remain identical). An increased ration supplement of ascorbic acid might not lead to maximum benefit unless the factor were incorporated in foods which were relished by the soldier or were given in a preformed state under strict supervision. It is also emphasized that if vitamin C is incorporated in ration items the amount should be generous enough to allow for losses which result from the time the food is processed until actually ingested. Thus the suggested 70% increase may well be modified in one direction or the other depending on the acceptability of the food or the stability of the factor after incorporation in the food.

Ironically, the 1951-52 dietary regime for soldiers failed to improve appreciably their values of serum vitamin C when compared to those reported among civilians. The fact that nearly every third soldier among 1,698 showed ranges of 0.018 to 0.29 mgm. ascorbic acid per 100 cc. of serum was considered highly significant. From the viewpoint of potential wounds, hemorrhage, physiological and psychological stresses (exposure, missed meals, dehydration, fear, exhaustion) problems much less constant among civilian populations, the soldier was not adequately protected with respect to vitamin C.

V. SUMMARY AND CONCLUSIONS

Studies by means of interviews and ascorbic acid determinations of blood and urine of 228 frostbite casualties and 1,693 normal combat soldiers indicated the following:

1) Soldiers who subsisted solely on combat rations ingested approximately one half to one third of the calories normally required for satisfactory nutrition and performance in the cold.

2) The discarding of the coffee and cocoa powders in the packaged combat ration, which contained the majority of the daily supply of ascorbic acid, necessarily reduced the vitamin C intake to a low level.

3) The hospital diet (Osaka Army Hospital) maintained or slightly improved the initial vitamin C concentration of the blood of frostbite casualties.

4) There was an inverse relationship in frostbite cases between the initial concentration of serum ascorbic acid and the number of days of supplementation of vitamin C (250 mgm.) required to saturate the serum with ascorbic acid. The utilization of ascorbic acid by the frostbite casualty was high.

5) The vitamin C concentration of sterile vesicular fluid was directly related to the amounts found in the serum.

6) There was no correlation between the levels of vitamin C and cold hemagglutinin titers in identical sera of normal soldiers or in sera of frostbite patients.

7) Low serum ascorbic acid concentrations were more frequent among patients with severe frostbite (third and fourth degree). More proof is needed, however, that the utilization of vitamin C depends upon the severity of the injury.

8) The diets of soldiers resulted in values of serum ascorbic acid comparable to those reported in the literature for normal adult

male civilians.

9) Using a titration method for the determination of vitamin C, 50% of 1,698 healthy United States soldiers stationed in the Far East exhibited serum ascorbic acid levels which averaged 0.5 mgm. per 100 cc. This value was considered to be low compared to normally accepted standards.

VI. RECOMMENDATIONS

1. To provide a higher "margin of safety" with respect to vitamin C, it is estimated that the soldiers diet should be supplemented with at least 70% more vitamin C than the amounts provided in 1951-52.

a. Studies should be made to ascertain whether such an increase could be modified in accordance with improvements pertaining to:

1) Degree of stabilization of vitamin C food (as provided at present).

2) Acceptability by soldiers of vitamin C containing foods.

3) Reduction of kitchen and plate waste.

b. It is strongly recommended that ascorbic acid be given in a preformed state under strict supervision. The daily oral administration of 200 mgm. of vitamin C to all soldiers would ensure satisfactory blood concentrations.

2. Convalescent frostbite patients should receive 200 mgm. of ascorbic acid daily in addition to the standard hospital diet in order to ensure satisfactory blood levels of vitamin C.

3. Knowledge of the effect of stress, in general, on the levels

of vitamin C in blood, urine and tissues of man is very meager. A study of the ascorbic acid alterations, as part of an index to adrenal cortical activity, under the stress of military activities might contribute to a better understanding of this problem.

4. The human requirements for vitamin C in a cold environment is still unknown. Studies of the vitamin C requirement by the soldier in a cold environment were recommended, following the completion of Exercise Shiver, by the staff of the Army Medical Nutrition Laboratory and are again worthy of recommendation. The following points are to be emphasized:

1) For better evaluation of the vitamin C requirement by the soldier ascorbic acid not only in blood, urine and excreta but also in tissues must be measured. Levels of vitamin C in the leukocyte-platelet fraction and the ascorbic acid-dehydroascorbic acid partitions are worthy of consideration.

2) Since, under wartime conditions, adequate nutrition (specifically with reference to the intake of water and calories) is often temporarily sacrificed in order to accomplish a mission, evaluation of the vitamin C requirements by the soldier should be made with reference to the quality and quantity of food prevailing under combat conditions.

3) Merely estimating the vitamin C content of foods, as received in the raw unprocessed state, is not accurate enough in evaluating the amount of vitamin C ingested. Because of the ease with which the factor is destroyed,

a more accurate estimate of the vitamin C content of foods is that obtained from chemical analysis of foods sampled at the same time the foods are ingested by the soldier.

VII. BIBLIOGRAPHY

1. Dugal, L. P. and M. Therin. Ascorbic acid and acclimatization to cold environment. Canad. J. Research, (E) 25: 111-136, 1947.

2. Dugal, L. P. and G. Fortier. Necessite de l'acid ascorbique pour l'acclimatation du singe (Rhesus) au froid. Compt. rend. Acad. d.s.c. 234: 138-140, 1952.

3. Whayne, T. F. Cold injury in World War II: A study in the epidemiology of trauma. Thesis for Dr. P. H. Harvard Sch. of Public Health, Washington, D. C. Office of the Surgeon General, Dept. of the Army, 1 May 1950.

4. Ferrer, M. I. Cold injury, transactions of the first conference 4-5 June 1951, New York, Josiah Macy, Jr. Foundation, 1951.

5. Mitchell, C. R. and M. Erdman. Nutrition and climatic stress with particular reference to man. Springfield, C. C. Thomas Company, 1951.

6. Glickman, N., R. W. Keeton, H. H. Mitchell and M. K. Fahnestock. The tolerance of man to cold as affected by dietary modifications. High versus low intake of certain water-soluble vitamins. Am. J. Physiol. 146: 538-558, 1946

7. Kark, R. M., R. E. Johnson and J. S. Lewis. Defects of pemmican as an emergency ration for infantry troops. War. Med. 7: 345-352, 1945.

8. Johnson, R. E. and R. M. Kark. Environment and food intake in man. Science 105: 378-379, 1947.

9. Golden, W. R. C. and H. S. Schechter. Vitamin C status of troops in the tropics. Bull. U. S. Army Med. Dept. 4: 710-717, 1945.

10. Carney, H. M. Wound healing with low vitamin C level. Ann. Surg. 123: 1111-1119, 1946.

11. Johnson, R. E. A field nutritional laboratory. War Med. 7: 222-226, 1945.

12. Bowes, A. deP. and C. F. Church. Food values of portions commonly used, Philadelphia, College Offset Press, 1946.

13. Parrott, E. M., T. E. Friedemann, C. F. Consolazio, W.J. Kuhl, W. R. Best, H. J. Krzywicki, R. W. Powell, J. E. Farley, C. H. Gates, L. J. Caranna and W. M. DeCrease. Nutrition survey of a company mess, Fort Sheridan, Illinois. Rept. No. 100, Chicago, Army Med. Nutrition Laboratory, 27 Aug. 1952.

14. Jolliffe, N. Preventative medicine in modern practice, New York, P. Hoeber Co., 79-120, 1942.

15. Food Nutrition Board, Nat. Acad. of Sci. Recommended dietary allowances. Reprint and circular series No. 122, Washington, D. C., National Research Council, Aug. 1945.

16. Swain, H. L., F. M. Toth, F. C. Consolazio, W. H. Fitzpatrick, D. I. Allen and C. J. Koehn. Final report of three nutrition surveys of Fort Churchill, Manitoba, Canada, 1947-48. Rept. No. 40, Chicago, Army Med. Nutrition Laboratory, 15 Oct. 1948.

17. Kaser, M. M., R. C. Steinkamp, W. P. Robinson, E. W. Patton and J. B. Youmans. Comparison of the calculated and determined calorie and vitamin contents of mixed diets. Am. J. Hyg. 46: 297-325, 1947.

18. Krehl, W. A. and R. W. Winters. Effects of cooking methods on retention of vitamins and minerals in vegetables. J. Am. Dietet. A. 26: 966-972, 1950.

19. Food and Nutrition Board, Nat. Acad. of Sci. Recommended daily dietary allowances. Reprint and circular series No. 129, Washington, D. C., National Research Council, Oct. 1948.

20. Canadian Council on Nutrition, Bull. No. 1 Vol. II, Ottawa, The Canadian Council on Nutrition, March 1950.

21. British Accessory Food Factors Committee. Vitamin C requirements of human adults. Experimental study of vitamin deprivation in man. Lancet 1: 854-858, 1948.

22. Consolazio, C. F., R. E. Johnson and E. Marek. Metabolic methods, St. Louis, C. V. Mosby Company, 1951.

23. Youmans, J. B., E. W. Patton and R. Kern. Surveys of the nutrition of populations. Am. J. Pub. Health 32: 1371-1379, 1942.

24. Wyatt, J., J. S. L. Browne and F. Ingersoll. Metabolic aspects of damage and convalescence. IV Ascorbic acid metabolism after damage in man with particular reference to coronary occlusion and myocardial infarction. National Research Council of Canada, Proc. of 10th meeting of the Assoc. Committee on Army Med. Res., Ottawa, Canada. 31 Jan. 1947.

25. Sweaney, H. C., C. L. Clancy, M. H. Redford and V. Hunter. The body economy of vitamin C in health and disease with special studies in tuberculosis. J.A.M.A. 116: 469-474, 1941.

26. Lowry, O. H., O. A. Bessey, M. J. Brock and J. A. Lopez. The inter-relationship of dietary serum, white blood cell and total body ascorbic acid. J. Biol. Chem. 166: 111-119, 1946.

27. Crandon, J. H., C, C. Lund and D. B. Dill. Experimental human scurvy. New England J. Med. 223: 353-369, 1940.

28. Faulkner, J. M. and F. H. L. Taylor. Vitamin C and infection. Ann. Int. Med. 10: 1867-1873, 1937.

29. Goldsmith, G. A. and G. F. Ellinger. Ascorbic acid in blood and urine after oral administration of a test dose of vitamin C; saturation test. Arch. Int. Med. 63: 531-546, 1939.

30. Ralli, E., G. J. Friedman and S. Sherry. The vitamin C requirement of man. Estimated after prolonged studies of the plasma concentration and daily excretion of vitamin C in 3 adults on controlled diets. J. Clin. Investigation. 18: 705-711, 1939.

31. Lewis, J. S., C. A. Storvick, R. M. Hauch, I. Patterson, S. Higano, B. Hawthorne. Renal threshold for ascorbic acid in twelve normal adults, with a note on the state of tissue reserves of subjects on an intake of ascorbic acid approximating the suggested daily allowance. J. Nutrition. 25: 185-196, 1943.

32. Klosterman, A. M., J. E. Haines, H. M. Hauck and A. B. Kline. The renal threshold for ascorbic acid. A modified method for its estimation with results for twelve adult subjects. J. Nutrition. 33: 505-509, 1947.

33. Berryman, G. H., C. R. Henderson, C. E. French, J. T. Goorley, H. A. Harper, H. Pollack and D. M. Harkness. Some factors influencing the biochemical appraisal of group nutritional status. Am. J. Physiol. 145: 625-631, 1945-1946.

34. Johnson, R. E., C. Henderson, P. F. Robinson and F. C. Consolazio. Comparative merits of fasting specimens, random specimens and oral loading tests in field nutritional surveys. J. Nutrition. 30: 89-98, 1945.

35. Browne, J. S. L., V. Schenker and J. A. F. Stevenson. Some metabolic aspects of damage and convalescence. J. Clin. Investigation. 23: 932, 1944.

36. Howard, J. E., W. Parson, K. E. Stein, H. Eisenberg and V. Reidt. Studies on fracture convalescence. I. Nitrogen metabolism after fracture and skeletal operations in healthy males. Bull. Johns Hopkins Hosp. 75: 156-168, 1944.

37. Rosenberg, H. R. Chemistry and physiology of vitamins. New York, Interscience Publishers Inc. 316-319, 1942.

38. Berryman, G. H., C. E. French, H. A. Harper and H. Pollack. Response to the intravenous injection of ascorbic acid as indicated by the urinary excretions of the total and reduced forms. J. Nutrition. 27: 309-313, 1944.

39. Melnick, D., M. Hochberg and B. L. Oser. Physiological availability of the vitamins. J. Nutrition. 30: 67-79, 1945.

40. Kark, R. M., R. E. Chapman, C. F. Consolazio and C. Nesby. Human ascorbic acid requirements in "damage" and its relationship to adrenocortical activity. Proc. Central Soc. for Clin. Res. (Chicago) 25: 48-49, 1952.

41. Bryan, A. H., D. F. Turner, R. L. Huenermann and G. Lotwin. The relation between plasma and dietary ascorbic acid. Am. J. M. Sc. 202: 77-83, 1941.

42. Kastlin, G. J., C. G. King, C. R. Schlesinger and J. W. Mitchell. Chemical methods for the determination and clinical vitamin C (ascorbic acid) deficiency. Am. J. Clin. Path. 10: 882-893, 1940.

43. Holmes, F. E., G. E. Cullen and W. E. Nelson. Levels of ascorbic acid in the blood plasma of apparently healthy children. J. Pediat. 18: 300-309, 1941.

44. Food Nutrition Board, Nat. Acad. of Sci. Inadequate diets and nutritional deficiencies in the U. S. Their prevalence and significance. Washington, D. C. Bull. Nat. Res. Council. 109: 1943.

45. Committee on Nutrition Surveys, Nat. Acad. of Sci. Nutrition surveys: Their techniques and value, Washington, D. C. Bull. Nat. Res. Council. 117: May 1949.

46. Andreae, W. A., and J. D. L. Browne. Vitamin metabolism in damage and convalescence. Rept. No. C-6225, Oct. 1931, Assoc. Committee on Army Medical Research National Research Council of Canada, Ottawa, Canada. 1945.

47. Andreae, W. A. and J. D. L. Browne. Ascorbic acid metabolism after trauma in man. Canad. M. A. J. 55: 425-432, 1946.

48. Ingall, T. H. and H. A. Warren. Asymptomatic scurvy. Its relation to wound healing and its incidence in patients with peptic ulcer. New England J. Med. 217: 443-446, 1937.

49. Rinehart, J. F., L. D. Greenberg, F. Baker, S. R. Mettier, F. Bruckman and F. Choy. Metabolism of vitamin C in rheumatoid arthritis. Arch. Int. Med. 61: 537-552, 1938.

50. Croft, J. D. and L. D. Snorf. Cevitamic acid deficiency frequency in a group of 100 unselected patients. Am. J. M. Sci. 198: 403-408, 1939.

51. Bartlett, M. K., C. M. Jones and A. E. Ryan. Vitamin C studies on surgical patients. Ann. Surg. 111: 1-26, 1940.

52. Hollinger, M. A. and R. B. Attaya. Comparison of the ascorbic acid content of plasma and of whole blood as criteria of nutritional status. J. Nutrition. 37: 203-213, 1949.

53. Goldsmith, G. A., A. T. Ogaard and D. F. Gowe. Vitamin C (ascorbic acid) nutrition in bronchial asthma; an estimation of daily requirement of ascorbic acid. Arch. Int. Med. 67: 597-608, 1941.

54. McDevitt, E., M. A. Dove, R. F. Dove and I. S. Wright. Vitamin status of the population of the west coast of Newfoundland with emphasis on vitamin C. Ann. Int. Med. 20: 1-11, 1944.

55. Harris, P. L., K. C. D. Hickman, J. L. Jensen and T. D. Spies. Survey of the blood plasma levels of vitamin A, carotene, ascorbic acid and tocopherols of persons in an area of endemic malnutrition. Am. J. Pub. Health 36: 155-160, 1946.

56. Horwitt, M. K. Ascorbic acid requirement of individuals in a large institution. Proc. Soc. Exper. Biol. & Med. 49: 248-250, 1942.

ARMY MEDICAL RESEARCH LABORATORY

FORT KNOX, KENTUCKY

REPORT NO. 113
1 April 1953

COLD INJURY - KOREA 1951-52*

Section XIII
COLD HEMAGGLUTINATION STUDY, KOREA, 1951-52
Part I - Techniques in the Cold Hemagglutinin Test

*Subtask under Environmental Physiology, AMRL Project No. 6-64-12-028, Subtask (8K), Cold Injury Studies.

MEDICAL RESEARCH AND DEVELOPMENT BOARD
OFFICE OF THE SURGEON GENERAL
DEPARTMENT OF THE ARMY

SECTION XIII

COLD HEMAGGLUTINATION STUDY

KOREA, 1951-52

Part I: Technique of the Cold Hemagglutinin Test

by

Bruce M. Hiser
Captain, MC, AUS

TABLE OF CONTENTS

COLD HEMAGGLUTINATION STUDY
KOREA, 1951-52

Part I: Technique of the Cold Hemagglutinin Test

I. INTRODUCTION

The term "cold hemagglutination" applies to a non-specific agglutination of erythrocytes in cold as a result of a reaction between antigen in the stroma of erythrocytes and hemagglutinin in the homologous serum or in the sera of others of the same or different species. The accepted criteria (1) which characterize this reaction are: 1) a predilection for maximum agglutination in the temperature zone just above freezing (0° to 5° C.); 2) a complete lack of specificity such that the antibodies are auto-agglutinating, iso-agglutinating, and hetero-agglutinating and 3) a gradual but complete reversibility of the reaction as the temperature is raised or lowered through a critical temperature zone.

The agglutinin is separable by absorption, is independent of the various known specific hemagglutinins, has been identified chemically as a euglobulin (2) and has the electrophoretic mobility of a gamma globulin (3).

Cold hemagglutination was first described in animals by Landsteiner in 1903 but was reported also in humans the same year by Biffi (1). It since has been the subject of innumerable reports.

Certain confusion in terminology exists because some type-specific agglutinins also have predilection for reaction in cold temperatures and as such could be classed as "cold agglutinating". These specific agglutinins should not be included under the term

"cold hemagglutinin" because the latter term automatically implies lack of specificity.

The usual thermal zone of reactivity of cold hemagglutinins is between 0° and 20° C. (1). Some uncommon agglutinins which fit the definition of cold hemagglutinins in every other respect, do not require cold temperature for the reaction to occur. The term auto-agglutinin is sometimes used to indicate this non-specific hemagglutinin which has a thermal range of activity extending over 20° C. Since the term auto-agglutinin is used also in referring to one of the general characteristics of cold hemagglutinins, the meanings of terms again becomes confused.

Terminology comparable to that defined by Stats and Wasserman (1) will be used in this report. Cold hemagglutination will refer to that reaction fitting the criteria set forth in the opening paragraph of this report, and the qualification "high thermal amplitude" will be applied when referring to those exceptional cases in which temperature below 20° C. is not essential.

The incidence of positive cold agglutination tests in healthy individuals presented in various reports in literature differ widely (1). Probably some of the confusion on the subject arises because the basic cause and physiological role of cold hemagglutinins are unknown. A vast majority of investigators have attempted to identify cold agglutinins with some pathologic process and minimum consideration has been given to their occurrence as a normal phenomenon.

The technique of the test may have been the principal cause for disparity in results reported in various investigations of cold hemag-

glutination. The problem of standardizing a technique has occasionally been a source of concern among workers studying cold hemagglutination (1). This concern is aptly summarized in the following quotation by Savonen (4): "...Various investigators differ markedly not only in their technique of investigation but also in the reason for their appraisal of the results. Some consider it important that the serum be separated from the heated blood sample while others assign no significance to the temperature at which serum is separated. Some investigators emphasize that the serum should be tested in the fresh state while others are testing samples of serum that are several months old. The erythrocyte concentration in the final dilution varies between 0.25% and 5%, and some investigators use fresh erythrocytes, while others use erythrocytes that are one week old. The incubation period may vary between some minutes and 24 hours. Furthermore, some investigators read their results with the naked eyes, while others use a loup, and others a microscope. Some authors reckon the degree of dilution of serum to be that which was ascertained before the addition of the erythrocyte suspension, while others take the degree of dilution to be the one which the serum has after the addition of the erythrocytes. Considering these points, we realize how uncritical it would be indiscriminately to compare the results reported by different investigators."

During the process of determining 11,000 cold hemagglutinin titers in the present investigation certain erratic features of the test were encountered and modified. In order to attempt rational interpretation of the results with respect to frostbite a rather

extensive evaluation of the test itself was inevitable.

The purposes of this part of the report are:

1) To show which technical procedures were responsible for grossly erroneous results and what modifications were introduced.

2) To justify exclusion of portions of the data shown to be unreliable.

3) To indicate the limitation of accuracy of those data obtained by the modified method.

II. METHODS

A. Subjects

All cold hemagglutination tests were done at the Cold Injury Center of Osaka Army Hospital, Osaka, Japan between 24 November 1951 and 17 April 1952.

Blood samples were obtained from United States soldiers who incurred frostbite in Korea and from a control group of combat soldiers, comparing with the frostbite group as nearly as possible from the standpoint of echelon of combat activity in Korea. Since frostbite is an injury primarily of front-line battalion troops, the original plan was to accept only similar combat infantrymen for the control group. Subsequently it became necessary, however, to include rear echelon troops as well as those from forward areas. As a check on the titer results from soldiers stationed in Korea, titers were also performed on the sera of replacement troops arriving in Japan from the United States and Hawaii.

It will be noted (Table 1) that the control samples were obtained from three different populations:

1. United States soldiers stationed in Korea. The samples were obtained in Korea and air transported to Osaka for testing. This group will be referred to as Korea Controls.
2. United States soldiers arriving at the Rest and Recuperation Center in Osaka, Japan from Korea for a brief leave from combat duty. This group will be referred to as the R and R Controls.
3. Replacement soldiers arriving at Camp Drake from the United States or Hawaii. This group will be referred to as the Camp Drake Controls.

All sera from frostbite patients (Table 1) were obtained after they were admitted to Osaka Army Hospital with the exception of 120 sera collected at the 25th Evacuation Hospital, Taegu, Korea and flown to Japan. A single sample was obtained from each control subject whereas the majority of frostbite patients were retested one to eight times. Certain items dealing with different phases of technique of the test are included in Table 1. References will be made to these factors in the discussions which follow.

B. Procedures

The initial method of determining cold hemagglutinin titers was similar to that summarized by Weiner (5), with the addition of a presumptive test comparable to that described by

TABLE I
SUMMARY OF COLD HEMAGGLUTINATION TESTS PERFORMED ON U. S. TROOPS
KOREA, 1951-52

Method	Source of Blood Samples	Site of Drawing Blood Samples	Dates Samples Drawn	Number of Tests	Sample Lots Tested at One Time: No. of Lots	Sample Lots Tested at One Time: Size of Lots: Mean	Sample Lots Tested at One Time: Size of Lots: Range	Age of Samples (Days from Date Sample Drawn to Date Titer read): Mean	Age of Samples (Days from Date Sample Drawn to Date Titer read): Range	Age of Erythrocyte Suspension (Days)	Reader of Titers: GEC	Reader of Titers: EMW
(Method A)	Controls	Korea	24 Nov. to 12 Jan	3387	11	303	37-818	6.5	4-9	0-2	2840	547
	Controls	R.andR. Center	9 Jan. to 19 Feb.	2254	17	133	[illegible]6-211	3.3	3-5	0-2	2190	64
	Controls	Camp Drake, Japan	11 Feb.	587	1	587	-	4.0	-	0-2	587	0
	Frost-bite Patients	Osaka Army Hosp.	29 Nov. to 19 Feb.	1181	26	45	4-175	2.0	1-3	0-2	1181	0
(Method B)	Controls	R.andR. Center	21 Feb. to 15 Apr.	2003	24	83	41-130	2.2	2-4	0	1671	332
	Controls	Camp Drake, Japan	2 Apr. to 8 Apr.	690	4	172	163-179	2.0	-	0	690	0
	Frost-bite Patients	Osaka Army Hosp.	[illegible] Feb. to 1 Apr.	1036	20	52	10-109	1.5	1-6	0	922	114

Young (6) in order to eliminate negative sera before complete titrations were carried out. A major modification in technique was introduced by reading the titers inside a walk-in refrigerator at a temperature of 0° C. instead of in a warm room. The original technique involving a presumptive test and reading done in a warm room (approximately 25° C.) will be referred to as Method A. The modified technique in which the screening test was eliminated and readings were done in a walk-in refrigerator will be referred to as Method B.

The following outlines present the details of each method.

1. Method A

a. Handling of Blood Samples

Blood samples (5-10 cc.) drawn by venepuncture were allowed to clot in clean test tubes (13 x 100 mm.). Samples were processed as soon after they were drawn as possible. If delay was unavoidable, samples were stored temporarily in the refrigerator at 0° to 4° C., except for the specimens sent from Korea. Storage temperatures of the latter, while enroute, were admittedly varied.

b. Separation of Sera

The whole blood samples were incubated in a 37° C. water bath for one hour, centrifugalized for 30 minutes and the sera decanted.

c. Preparation of Erythrocyte (Antigen) Suspension

Two cc. of Group O whole blood were added directly to 13 cc. physiological saline solution in a 100 cc.

centrifuge tube before clotting could occur. The erythrocytes were washed three times in physiological saline solution and then diluted with physiological saline to a 1% suspension by accurate measurement. The same donor was usually used. Suspensions were used for 2 days and then discarded.

d. Presumptive or Screening Test

To 0.5 cc. of each serum sample in clean dry test tubes was added 0.5 cc., 1% Group O, erythrocyte suspension. These mixtures were refrigerated and readings carried out as indicated below. Negative readings were recorded as negative and only positive sera were titrated further.

e. Titration of Positive Sera

Serial dilutions of sera were prepared with physiological saline solution using a doubling serological transfer method. The serum dilutions before the addition of antigen were as follows:

Tube Number	1	2	3	4	5	6	7	8	9
Dilutions of Sera before Antigen Added	1:1	1:2	1:4	1:8	1:16	1:32	1:64	1:128	1:256

To each tube was added 0.5 cc. of 1% erythrocyte suspension so that the final serum dilutions were as follows:

Tube Number	1	2	3	4	5	6	7	8	9
Dilutions of Sera after Antigen Added	1:2	1:4	1:8	1:16	1:32	1:64	1:128	1:256	1:512

f. Refrigeration

The racks containing titration mixtures were placed in a six cubic foot upright refrigerator and allowed to remain at 0° to 4° C. for 16 to 20 hours.

Three refrigerators with a six cubic foot volume were used for the Method A tests. Each refrigerator could hold 40 Wassermann racks. A maximum of 400 presumptive tests or 80 to 160 complete titrations could be stored at one time in each refrigerator.

g. Titer Readings

The reading of the titrations was carried out in the immediate proximity of the refrigerators. One rack at a time was removed from the refrigerator, placed in a bath of ice water (which surrounded the lower one-third or one-half of the tubes) and the agglutination reactions read immediately. The room temperature was approximately 25° C. Each tube was wiped with a towel and after two light inverting agitations examined through a magnifying glass (magnifier 40 mm., 3.5 lens) using a moderate light source (small microscope lamp).

Each tube was read as either 4+, 3+, 2+, or 1+ according to the following criteria:

4+ All erythrocytes completely agglutinated into a large mass or into clumps.

3+ Clumps smaller but surrounding fluid still clear.

2+ Coarse granular clumps in surrounding fluid pinkish from suspended erythrocytes.

1+ Fine but definitely granular clumps with surrounding fluid pinker from increased proportion of suspended erythrocytes.

± Indefinite granular appearance.

0 Negative. Fine evenly divided suspension of erythrocytes without evidence of clumping.

h. Recording Titer Values

The titer of the serum was the highest final dilution (antigen added) in which 1+ agglutination occurred.

i. Rewarming Titrations

As a check on the resolution of the agglutinations, titrations were examined 1 to 2 hours after standing at room temperature.

2. Method B - Modification of Cold Hemagglutination Test

a. Blood Samples

Whole blood samples were stored at room temperature where delay in separating sera was unavoidable. They were never stored as whole blood longer than 16 hours.

b. Separation of Sera

Same as in Method A.

c. Preparation of Erythrocyte Suspensions

A single Group O donor was used throughout (except in experiments dealing with the effect of varying the source of antigen). Only freshly prepared erythrocyte suspensions were used.

d. Presumptive or Screening Test

Eliminated.

e. Titration of Sera

Same as Method A.

f. Refrigeration

Titration mixtures were placed in a walk-in refrigerator (300 cubic foot capacity) where the ambient temperature ranged from -2° to +2° C.

g. Reading

Reading of the titer tubes was performed inside the walk-in refrigerator. This obviated the necessity for ice water baths and wiping of tubes to remove frosting and water from the outside surfaces of the tubes.

h. Recording Titer Values

Emphasis was placed on the distinction between 1+, 2+, 3+ and 4+ agglutinations and use made of different titer levels which may be defined as follows:

1+ titer - Corresponded with the highest final dilution in which a 1+ agglutination occurred.

2+ titer - Corresponded with the highest final dilution in which a 2+ agglutination occurred.

3+ titer - Corresponded with the highest final diltuion in which a 3+ agglutination occurred.

4+ titer - Corresponded with the highest final dilution in which a 4+ agglutination occurred.

EXAMPLE:

Tube Number	1	2	3	4	5	6	7	8	9
Final Serum Dilutions	1:2	1:4	1:8	1:16	1:32	1:64	1:128	1:256	1:512
Agglutination	4+	4+	4+	3+	2+	2+	1+	1+	0

4+ Titer: 1:8
3+ Titer: 1:16
2+ Titer: 1:64
1+ Titer: 1:256

All four titer values were recorded for each sample. This type of observation permitted quantitation of the degree of agglutination and an indication as to the amount of agglutinin present in each specimen.

i. Rewarming Titrations

Same as in Method A.

C. Methods of Analysis

When a sufficient number of cold agglutination titers are done on any homogeneous group the results follow a frequency

distribution pattern just as do other biological phenomena. The position and shape of the distribution curve are dependent on the following factors: 1) class intervals designating titer values, 2) sensitivity of the method of testing and 3) peculiarities intrinsic to the individuals of the groups being studied.

In handling the class intervals there were two possibilities: 1) actual dilution values constituting in these experiments the geometric series 2, 4, 8, 16, 32, 64 etc. or 2) coded values, such as logarithmic function of the dilution. The latter procedure, in the form of the following coding system, was employed in all calculations:

Titer	Neg.	1:2	1:4	1:8	1:16	1:32	1:64	1:128	1:256	1:512	1:1024
Coded Titer Value	0	1	2	3	4	5	6	7	8	9	10

The coded titer value represents the highest tube number in which positive agglutination (1+) was found. Since dilutions were doubled in each successive tube, the tube number, that is, the coded titer value, actually represents the exponent to the base two (e.g. 1:64 equals 2^6).

The justification for this coding system was that it tended to normalize most of the distributions analyzed, a distinct advantage in enabling fairly accurate visualization of titer distributions from information as to the means

and standard deviations. Also the system simplified calculations without altering results of "r" or "t" tests.

The types of curves obtained using this coding system varied from a Poisson curve to a normal frequency curve depending on the sensitivity of the method involved and on the characteristics and homogeneity of the group being tested. As will be shown in Part II, the Method B titers of groups with the greatest degree of homogeneity for factors which seemed to influence cold hemagglutination occurred as normal frequency distributions.

Statistical methods used in the analyses included the "t" test, the correlations "rho" and "r" and the various methods of chi square. In frequent instances, comparisons were made between two sets of samples taken from the same group of individuals, where the two sets showed a high degree of correlation. The test for significant difference in the means of such correlated samples involved the formula which incorporated the "r" value in the calculation of sigma of the difference.

III. RESULTS

A. Reader Reliability

One of the most critical aspects to the determination of cold hemagglutinin titers is the ability of the experimentalist to reproduce his readings with a high degree of reliability. Since no experimental procedure was designed to derive an index of reader reliability an attempt was made to assess

this important factor by utilizing the data described in detail under a subsequent section (III C) entitled "Effects of Temperature Variations on Cold Hemagglutination". These data consisted of 80 blood samples titrated in duplicate and read on two successive days according to Method B.

In Table 2 are shown the coded titer values for the duplicated titrations as randomly read by the same individual (G.E.C.). In addition the differences are presented between the individual readings as well as other statistical measures. A statistically significant difference was found between the means of the first and second readings as attested by a "t" value of 9.815. Perusal of the table reveals that the changes in titer values were for the most part in the same direction, namely, a reduction in titer value for the second set of titrations. If the difference of the means had resulted from the readers variability one would not have anticipated such consistency of titer values in one direction. A "t" value of 0.164 proved that the above mean difference recorded in Table 2 did not deviate significantly from the difference of means for the two readings (0.95). Thus it can be postulated that the factor which contributed most heavily to the significant difference was the effect of rewarming on the second set of titrations during the transfer process. Further reliability of the reader was indicated by the high positive correlation coefficient of 0.859 obtained between the first and second

TABLE 2

CORRELATION OF COLD HEMAGGLUTININ TITER VALUES FOR DIVIDED SAMPLES IN A TEST OF READER RELIABILITY

Sample No.	Coded Titer Value (1)	Coded Titer Value (2)	Diff. Between (1) and (2)	Sample No.	Coded Titer Value (1)	Coded Titer Value (2)	Diff. Between (1) and (2)
1	6	6	0	41	7	6	-1
2	3	2	-1	42	6	6	0
3	4	4	0	43	3	3	0
4	2	2	0	44	6	6	0
5	5	4	-1	45	4	3	-1
6	2	2	0	46	4	2	-2
7	2	3	+1	47	5	3	-2
8	2	2	0	48	5	3	-2
9	2	2	0	49	5	3	-2
10	3	4	+1	50	4	2	-2
11	3	2	-1	51	3	1	-2
12	3	2	-1	52	4	3	-1
13	4	3	-1	53	2	1	-1
14	4	3	-1	54	4	3	-1
15	4	3	-1	55	3	2	-1
16	6	6	0	56	5	3	-2
17	2	1	-1	57	4	4	0
18	3	2	-1	58	2	2	0
19	3	2	-1	59	2	1	-1
20	6	5	-1	60	7	6	-1
21	5	4	-1	61	4	3	-1
22	2	1	-1	62	2	2	0
23	3	3	0	63	3	2	-1
24	6	6	0	64	5	4	-1
25	1	1	0	65	3	3	0
26	2	0	-2	66	4	2	-2
27	6	6	0	67	4	2	-2
28	4	4	0	68	7	6	-1
29	3	2	-1	69	4	3	-1
30	3	2	-1	70	4	3	-1
31	5	4	-1	71	3	3	0
32	4	2	-2	72	4	4	0
33	4	3	-1	73	4	3	-1
34	5	5	0	74	3	1	-2
35	6	5	-1	75	4	3	-1
36	5	4	-1	76	4	3	-1
37	6	4	-2	77	5	4	-1
38	4	2	-2	78	7	5	-2
39	7	6	-1	79	4	3	-1
40	1	2	+1	80	3	1	-2
				Mean	4.0	3.1	1.0
				S.D. ±	1.48	1.50	0.69

$t_{1-2} = 9.815$ $P < .001$

$r_{1-2} = +0.864$ $P < .001$

1% Confidence Limits +0.766 to +0.919

readings. This statistic indicates that the change in titer values noted was highly consistent suggesting the influence of factors other than that of reader inconsistency.

B. Refrigeration

The single physical factor most essential to the cold hemagglutination reaction is cold. The reversal of agglutination upon rewarming is recognized only as a characteristic of the reaction. Only in rare instances does this non-specific reaction occur at warm temperatures (25° to 37° C.).

The specifications for refrigeration in testing cold agglutination are usually given as between 0° and 5° C. for 12 to 16 hours. In reading titers, according to methods usually described, racks are removed from a refrigerator and read in a warm room, presumably before rewarming can occur. The rewarming effect of room temperature may or may not lead to error in instances of a single test or a small number of tests performed on one occasion. The experiences to be cited in the following paragraphs, however, suggest that error due to rewarming was great when a large number of tests were performed at any one time.

1. Method A - Korea Controls

A total of 3,387 whole blood samples, obtained from United States infantry soldiers, were shipped to Osaka from Korea between 24 November 1951 and 12 January 1952 (Table 1). These samples were shipped in 11 separate lots varying in size from 37 to 818 specimens. The tests

were carried out immediately upon arrival of samples in Osaka, so that the number of tests done at one time corresponded with the sizes of groups shipped from Korea. The time elapsed between the drawing of samples and the separation of sera ranged between 2 and 7 days, with an average of 4.5 days. Two additional days were required for completing titration and reading titers of each lot.

These titers were determined by Method A. The grand mean titer of Korea controls was 0.4. There was considerable variation in the mean titers of the separate lots (Table 3). No relationship was evident between the titer means and lot sizes where the number of samples were 200 or less. The three lots larger than 700, however, had very low titers. A statistical comparison between results from the eight lots of 200 or less and those of 700 or more showed the difference in titer means to be highly significant (Table 4).

TABLE 3

DISTRIBUTION OF LOTS ACCORDING TO SIZE AND MEAN TITER FOR KOREA CONTROLS

Lot Size	37	58	95	122	196	197	198	200	732	734*	818
Titer Mean	0.7	0.6	0.8	1.3	0.5	0.5	1.0	1.1	0.2	0.4	0.2

* The lot of 734 samples came from a Puerto Rican Regiment whereas the lots of 732 and 818 were obtained from individuals (predominately White) originating from the United States. Puerto Ricans were believed to have a predisposition to higher titers than either Whites or Negroes from the United States. (See Part II - Race)

TABLE 4

COMPARISON OF MEAN COLD HEMAGGLUTININ TITERS FOR THREE CONTROL GROUPS WITH RESPECT TO LOT SIZE

Control Group	No. of Lots	Range of Lot Sizes	N	Titer Mean	S. D.	t	P
Korea Korea	8 3	37 - 200 732 - 818	1103 2284	0.8 0.2	±1.24 ±0.64	14.825	<.001
Korea R. and R.	8 17	37 - 200 76 - 211	1103 2254	0.8 1.0	±1.24 ±1.23	3.476	<.001

2. Method A - R and R Controls

Because of certain unavoidable difficulties in obtaining blood samples in Korea and shipping them to Japan, the age and condition of Korea control samples varied widely. A more convenient source was from the Rest and Recuperation Center in Osaka, Japan. The one disadvantage of this source was that sampling could not always be restricted to front-line troops.

A total of 2,254 samples obtained at the R and R Center were tested by Method A during the period 9 January to 19 February 1952 (Table 1). The sera were separated and titrations performed the morning after (about 16 hours) samples were collected. The average time between collection of blood samples and completion of readings was 3.3 days with a range of 3 to 5 days. The results (disregarding race of individuals tested) are shown in Table 5 together with comparison with those of the Korea controls. The titers of R and R controls were significantly higher.

When the three largest groups (over 700) of Korea controls were excluded for a comparison between R and R controls the groups were more uniform in size (Table 4). The difference in titer mean (0.2), even though significant, was much smaller then the difference (0.6, Table 5) in the previous comparison between Korea and R and R control groups. Whether age and rough handling had any influence on lower results of Korea controls in these analyses can only be conjectured.

TABLE 5

COMPARISON OF MEAN COLD HEMAGGLUTININ TITERS OF
KOREA CONTROLS TO R AND R CONTROLS
ACCORDING TO METHOD OF PERFORMANCE

Control Groups		Method	N	Titer Mean	S.D.	t	P
Korea Control vs.		A	3387	0.4	±0.92		
	R & R	A	2254	1.0	±1.23	17.693	<.001
	R & R	B	1671	3.4	±1.58	69.694	<.001

3. Method A - Camp Drake Controls

The results of 587 tests done by Method A on sera of replacement troops arriving in Japan from the United States, had a mean titer of 0.6 which was comparable to the mean titers of the smaller groups of Korea controls. The condition of the samples from the replacement troops was good but the size of the group (tested at

one time) was larger.

4. Method B - R and R Controls

Concern over adequacy of refrigeration arose because of a poor correlation between results of presumptive tests and definitive titers. There was also a tendency for both presumptive tests and complete titrations to be positive during initial readings in a series and negative as readings of the lot progressed. The use of ice baths, to prevent rewarming of titration mixtures before being read, appeared to have little influence on the observations.

It was suspected that titers might be influenced by the room temperature, therefore facilities were obtained so that the cold hemagglutination test could be performed inside a 300 cubic foot walk-in refrigerator adjusted to maintain a temperature of 0° C. (Method B). A continuous temperature record made on a Frieze Thermograph indicated the average temperature was 0° C., with a cyclic flunctuation between -2° and +2° C.

Despite the drop of temperature below 0° C. freezing of the test tubes did not occur. Certain advantages in reading titers by this method were:

1) More distinct agglutinations with less tendency to reverse from over agitation.
2) Deletion of ice baths.

3) No opening and closing of refrigerator doors between readings, which had previously been factors of definite inconvenience.

4) The outside of the test tubes instead of becoming frosted remained clear and the necessity for wiping each tube during reading was obviated.

The Method B titers for R and R control sera were significantly higher than those of either Korea or R and R controls tested by Method A (Tables 5 and 6). Control samples were positive (98.6%) of which 68.8% had a titer of 1:8 or higher. The difference in these readings compared to those obtained in Method A was attributed mainly to the careful control of temperature (-2° to +2° C.) throughout the refrigeration and reading phases of the test.

TABLE 6

COMPARISON BETWEEN MEAN COLD HEMAGGLUTININ TITERS
OF R AND R CONTROL FOR METHODS A AND B

Race	Method	N	Titer Mean	S. D.	t	P
White	A	1619	0.9	±1.19	47.437	<.001
	B	1432	3.4	±1.55		
Negro	A	220	1.4	±1.39	13.735	<.001
	B	172	3.6	±1.66		

5. Method A and B - Frostbite Group

A total of 1,181 tests were performed on sera of 471 frostbite patients. The sera were tested in 26 separate

lots which had an average of 45 (range 4 - 175) specimens. Results of initial titers of 214 White and 191 Negro patients are shown in Table 7 along with analogous results from Method B titers for 126 White and 120 Negro frostbite patients. The comparisons showed that the Method B mean titers were significantly higher.

TABLE 7

COMPARISON BETWEEN MEAN COLD HEMAGGLUTININ TITERS OF FROSTBITE PATIENTS FOR METHODS A AND B

Race	Method	N	Titer Mean	S. D	t	P
White	A	214	1.5	±1.21	18.551	<.001
	B	126	4.3	±1.42		
Negro	A	191	2.1	±1.46	15.813	<.001
	B	120	4.7	±1.42		

C. Effect of Temperature Variations on Cold Hemagglutination

In order to elucidate the influence of temperature variations on titer values 80 sera were titrated in duplicate with one set being processed according to Method A and the other by Method B. Records were kept of the temperature inside the refrigerators during the experiment. The temperature inside the 300 cubic foot refrigerator fluctuated regularly between -2° and +2° C. averaging 0° C. There was a steady rise from -2° to +7° C. in the six cubic foot refrigerator during the 30 minute reading period. The individual titer values obtained by each method are shown in Table 8. Analysis indicated that in spite of significant positive correlation

(r = 0.602, P <.01) between titers by the two methods, the Method B titers were again significantly higher (t = 22.489, P <.001).

TABLE 8

TITER VALUES FOR DUPLICATE TITRATIONS OF 80 SERA PROCESSED SIMULTANEOUSLY BY METHODS A AND B

Sample No.	A*	B**	Sample No.	A*	B**	Sample No.	A*	B**	Sample No.	A*	B**
1	1:16	1:64	21	1:4	1:32	41	1:4	1:128	61	0	1:16
2	1:2	1:8	22	0	1:4	42	1:4	1:64	62	0	1:4
3	1:4	1:16	23	1:2	1:8	43	0	1:8	63	0	1:8
4	1:4	[illegible]	24	1:8	1:64	44	1:4	1:64	64	1:4	1:32
5	1:8	1:32	25	0	1:8	45	0	1:16	65	0	1:8
6	0	1:4	26	0	1:4	46	0	1:16	66	0	1:16
7	1:4	1:4	27	[illegible]	[illegible]	47	0	1:32	67	0	[illegible]
8	0	1:4	[illegible]	1:4	[illegible]	[illegible]	0	1:32	68	1:4	1:128
9	0	1:4	[illegible]	1:2	[illegible]	[illegible]	1:2	1:32	69	0	1:16
10	[illegible]	[illegible]	30	0	[illegible]	50	0	[illegible]	70	0	[illegible]
11	1:2	[illegible]	[illegible]	1:4	[illegible]	51	0	[illegible]	71	0	1:8
12	1:4	[illegible]	[illegible]	1:4	[illegible]	52	1:2	1:16	72	0	1:16
13	1:2	[illegible]	[illegible]	1:4	[illegible]	53	0	1:4	73	0	[illegible]
14	1:2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1:4	1:16	74	0	1:8
15	1:2	1:16	[illegible]	1:4	[illegible]	55	0	1:8	75	0	1:16
16	1:2	[illegible]	[illegible]	1:4	[illegible]	56	1:2	1:32	76	0	1:16
17	0	[illegible]	37	[illegible]	[illegible]	57	0	1:16	77	[illegible]	1:32
18	0	1:8	[illegible]	0	[illegible]	58	1:2	1:4	78	[illegible]	[illegible]
19	1:4	[illegible]	39	1:4	[illegible]	59	0	1:4	79	0	1:16
20	1:8	[illegible]	40	0	1:2	60	1:2	1:128	80	0	1:8
Means			A = 1.0 ± 1.07						B = 4.0 ± 1.48		

* Read in sequence
** Read at random

Inspection of Table 8 suggests that in addition to the Method A results being consistently lower, the titer values tended to decrease concomitantly with a rise in the refrigerator temperature. This relationship was analyzed by correlating the sample numbers with the two series of titer values. The Method B titer values had a positive correlation with the refrigerator temperature (r=+0.156) which was not significant (P >.05). By contrast,

the Method A values had a negative correlation ($r = -0.409$) which was significant ($P < .01$). The comparison between the two correlations showed a significant difference ($t = 5.263$, $P < .001$). These analyses show that for Method A there existed an inverse relationship between the titer value and refrigerator temperature.

Any error introduced by poor temperature control would depend not only on temperature rise within the refrigerator but also upon the warming effect of the room temperature as the tubes were being read. These influences cannot be expected to remain constant. The rise in temperature inside the refrigerator depended upon the following:

1) Frequency of opening the door.
2) Duration of each opening.
3) Total number of times opened.
4) Temperature of the room.
5) Efficiency of the refrigerator.
6) Volume of the refrigerator.

The extent of the warming effect resulting from exposing the titrations to room temperature during reading would likewise be inconstant. This effect depended upon the room temperature and time consumed with each reading.

The effect of warming on the agglutination either in the refrigerator or in the room would also be dependent upon the thermal amplitudes of the cold hemagglutinins being tested.

The evidence presented indicated that temperature variables

had an important bearing on results of the cold hemagglutination tests. Therefore maintenance of a constant temperature during refrigeration and reading was deemed necessary.

D. Age and Source of Antigen

The effect of the age of the erythrocyte suspension (antigen) was not investigated. All erythrocyte suspensions were prepared from freshly drawn O blood for Method B tests.

It is reasonable to expect that donors for erythrocyte suspensions might vary to some extent in antigenicity. To avoid such a variable the same donor was used for most of the Method A tests. Different donors were tried on a few occasions. The technician reading the titers, however, claimed greater difficulty in determining end points when blood other than that from the original donor (L.B.) was used. The source of antigen was restricted to one donor for the Method B tests.

Studies were made to test the effect of different Group O donors on titer values. In one study 24 sera were titrated in duplicate and the erythrocytes of L.B. used for one set and those of R.Z. in the other (Table 9). There was significant correlation between the two sets. The difference in the means was statistically significant.

In a second study 30 sera were titrated in duplicate. The erythrocytes of L.B. were used in the first set and cells of three different donors were used for the second group (10 determinations for each donor cell suspensions). The correlation between the two sets was significant (Table 9). There was a significant difference in the means of the two sets.

TABLE 9

THE EFFECT OF DIFFERENT ANTIGEN DONORS ON THE MEAN TITERS OBTAINED FROM IDENTICAL SAMPLES

Erythrocyte Donor	N	Titer Mean	S. D.	Correlation r	Correlation P	Comparison t	Comparison P
L.B.	24	4.2	±1.19	0.838	<.01	2.827	<.01
R.Z.	24	4.5	±1.24				
L.B.	30	3.9	±1.43	0.908	<.01	2.079	<.05
Combined	30	4.1	±1.45				

E. Storage of Blood Samples

A study was made relative to the manner of storing whole blood samples, namely whether cold agglutinin potency was maintained best at refrigerator or at room temperature. Prior to the initiation of the Method B test, the practice was to refrigerate the control samples and separate the sera in the morning. At times samples would freeze because of uneven refrigeration and the resulting hemolysis made the readings difficult and inaccurate. Consequently, the procedure was changed to storing samples at room temperature overnight.

Blood was drawn from 54 patients and each sample divided in half. One set of whole blood samples was stored overnight at room temperature, the other in the refrigerator. The following morning titrations were performed on both sets of samples by identical technique. There was significant correlation between the two sets of titers (Table 10). The mean titer value of the refrigerated samples was significantly lower than that of the bloods stored at room temperature.

It was concluded that storage of whole blood samples at

room temperature was as satisfactory as storage by refrigeration.

TABLE 10

COMPARISONS OF MEAN COLD HEMAGGLUTININ TITERS FOR DUPLICATED IDENTICAL SAMPLES STORED AT TWO DIFFERENT TEMPERATURES

Location of Storage	N	Titer Mean	S. D.	Correlation		Comparison	
				r	P	t	P
Refrigerator	54	3.8	±1.20	0.815	<.01	2.550	<.02
Room	54	4.1	±1.47				

IV. DISCUSSION

It was not intended that the studies presented here represent an exhaustive evaluation of the technique of testing for cold hemagglutination. Rather it was anticipated that they act as a guide to reliability of data accumulated specifically for the study of frostbite. Furthermore, if any part of the data was to be discarded as grossly inaccurate, the justification for such a selection had to be established.

The greatest emphasis was placed on careful control of temperature to which titration mixtures were subjected because it was apparent that poor control of temperature was the most important cause for variation in the bulk of tests performed by Method A. The six cubic foot refrigerator was admittedly inefficient for work of this type because of the small volume and relatively large door, a combination which readily leads to temperature rise within the refrigerator from repeated opening of the door. Another point to be emphasized is that the Method A readings were done in a room that was always warm and often overheated.

Direct evidence of an interaction between warm air and cold tubes

was readily apparent by the frosting of test tubes. Frosting tended to occur inside the refrigerator shortly after a series of Method A readings was started. It did not occur during the Method B readings unless the worker breathed directly on the tubes. How cool a room had to be to eliminate any substantial rewarming effect on titration mixtures was not studied. The reading of titers in an atmosphere of 0° C. eliminated any possibility of rewarming. This was the justification for using the Method B techniques. The high titer values obtained in Method B were rather surprising in view of the usually reported low incidence of this phenomenon in healthy individuals.

These studies on technique centered on reproducibility of results and the modifications designed to improve accuracy. Inaccuracies in Method B might be attributed to errors of titration and reading. The principal reader did have considerable practice in developing consistent reading (8,352 titers) before introduction of the modified method.

V. SUMMARY AND CONCLUSIONS

Standardization of the cold hemagglutination test was essential for the investigation of frostbite since conclusions were based on a statistical comparison of the titers of different groups of soldiers. Time did not permit an exhaustive study of all phases of methodology. For the sake of expediency, a choice had to be made of those procedures which seemed more reasonable or less controversial whether or not proof was established as to their superiority over alternate procedures. A general indication was presented of the limitations of accuracy experienced in performing cold hemagglutination tests by Methods A and B.

It was concluded that the titer values obtained by Method B were accurate and reproducible. Analyses showed that the technician reading the titers had a high degree of reliability and consistency.

VI. RECOMMENDATIONS

The recommendations as to optimum procedures (Method B) for performing the cold hemagglutination test were as follows.

A. Refrigeration and Reading Temperatures

Readings should be made in an environment in which the temperature varies but minimally and corresponds to the refrigeration temperature of the sample.

B. Erythrocyte Suspensions

The use of freshly drawn blood obtained from the same donor throughout should be the procedure of choice.

C. Method of Storage of Blood Samples

Storage of whole blood samples overnight should be at a room temperature of approximately 25° C.

VII. BIBLIOGRAPHY

1. Stats D. and L. R. Wasserman. Cold hemagglutination - an interpretive review. Medicine. 22: 363, 1943.

2. Clough, M. C. and I. M. Richter. A study of an autoagglutinin occurring in human serum. Bull. Johns Hopkins Hosp. 29: 86, 1918.

3. Stats, D., Z. Perlman, J. B. M. Bullowa and R. Goodkind. Electrophoresis and antibody nitrogen determinations of a cold hemagglutinin. Proc. Soc. Exper. Biol. and Med. 53: 188, 1943.

4. Savonen, K. Diagnostic significance of the cold agglutination. Acta med. Scandinav. 133: (Supp. 239) 133, 1950.

5. Weiner, D. The role of cold hemagglutinins in frostbite. Report No. 67. AMRL Project No. 6-62-12-Z, 1951.

6. Young, L. E. The clinical significance of cold hemagglutinins. Am. J. M. Sc. 211: 23, 1946.

ARMY MEDICAL RESEARCH LABORATORY

FORT KNOX, KENTUCKY

REPORT NO. 113
1 April 1953

COLD INJURY - KOREA 1951-52*

Section XIII
COLD HEMAGGLUTINATION STUDY, KOREA, 1951-52
Part II - Cold Hemagglutination in Relation to Frostbite

*Subtask under Environmental Physiology, AMRL Project No. 6-64-12-028, Subtask (8K), Cold Injury Studies.

[illegible]

MEDICAL RESEARCH AND DEVELOPMENT BOARD
OFFICE OF THE SURGEON GENERAL
DEPARTMENT OF THE ARMY

SECTION XIII

COLD HEMAGGLUTINATION STUDY

KOREA, 1951-52

Part II - Relationship of Cold Hemagglutination to Frostbite

by

Bruce M. Wimer
Capt., MC, AUS

TABLE OF CONTENTS

COLD HEMAGGLUTINATION STUDY
KOREA, 1951-52

Part II - Relationship of Cold Hemagglutination to Frostbite

I. INTRODUCTION

An extensive study of the relationship of cold hemagglutination to frostbite was motivated by the hypothesis that an individual's susceptibility to frostbite could be directly correlated with titer of cold hemagglutinins in his serum. Weiner (1) reported an investigation in which cold hemagglutinin titers were significantly higher in a group of individuals frostbitten in Korea during the winter 1950-51 than in 308 healthy soldiers stationed at Fort Knox, Ky. A theory was developed that intravascular agglutination might occur in conjunction with vasospasm and local chilling during exposure of a part to cold if a high cold hemagglutinin titer existed. Local tissue cooling and injury would then be due in part to hemic stasis associated with intravascular cold hemagglutination.

Occasional references have appeared in the literature suggesting a relationship between cold hemagglutination and cold susceptibility. An indication that cold hemagglutination might have some bearing on individual susceptibility to trenchfoot was stated by Parker (2) in a personal communication cited by Platt and Ward but no data were submitted to support this belief. Stats and Wasserman (3) suggested investigation of the possibility that individual tolerance to cold is dependent upon the titer of normal cold

hemagglutinins. In studies on experimental frostbite of rabbit limbs, Lange, Weiner and Boyd (4) reported observations of skin capillaries using a capillary microscope in which erythrocytes were seen to clump into irregular masses concomitantly with a halting of circulation just before freezing of tissue occurred. Immediately after thawing the reverse process was noted. Further investigation was suggested to determine if this phenomenon represented cold agglutination.

Similar descriptions of intravascular clumping have in fact been reported by Iwai and Mei-sai (5), Jessen and Bing (6), and Stats and Bullowa (7) in studies of individuals with potent cold hemagglutinins. These examinations were made on conjunctival vessels following lavage of the conjunctival sacs with cold isotonic saline solution. Reversal of the clumping occurred when warmth returned to the tissues.

The purpose of this study was to determine the relationship of cold hemagglutination to frostbite. One obstacle to this investigation was the lack of knowledge of just what forces determine inherited differences or acquired change in the amount of circulating cold agglutinin in normal individuals. The lack of information on this subject made it difficult to plan the experiment so as to control such forces.

II. METHODS

A. Subjects

The cold hemagglutinin titers analyzed in this part of the report were done on sera of frostbite patients, R and R control subjects and Camp Drake control subjects. The titers

from the frostbite group were designated either as the <u>initial titer</u> (first test) or the <u>modal titer</u> (most frequently occurring value). Because only one titration was performed for each control subject the initial titer for patients was used in analyses involving comparison between frostbite and control groups.

B. Procedure

All titrations were performed according to Method B as outlined in Part I and all titers were read by one technician (G.E.C.).

III. RESULTS

A. Intrinsic Factors and Cold Hemagglutination

1. Race

The make-up of various racial groups studied was as follows:

a) White - United States Caucasians.

b) Negro - United States Negroes.

c) Mongolian - Ancestry from the yellow race, mostly Japanese living in the United States or Hawaii.

d) Latin American - mostly individuals with Puerto Rican or Mexican ancestry.

e) Hawaiian - Native Hawaiians.

The titers of Negroes were significantly higher than those of Whites in all comparisons except the one involving R and R control subjects (Table 1). An ex-

TABLE 1

RACIAL COMPARISONS OF COLD HEMAGGLUTININ TITERS

Group	Racial Comparisons		No.	Mean Initial Titer	Standard Deviation	t	P
R and R Controls	White vs.		1432	3.4	±1.55		
		Negro	172	3.6	±1.66	1.659	>.05
		Latin American	18	3.9	±1.57	1.424	>.10
		Mongolian	20	4.5	±1.93	2.679	<.01
	Negro vs.		172	3.6	±1.66		
		Latin American	18	3.9	±1.57	0.725	>.40
		Mongolian	20	4.5	±1.93	2.051	<.05
	Latin American vs.		13	3.9	±1.57		
		Mongolian	20	4.5	±1.98	1.144	>.20
Frost-bite Patients	White vs.		126	4.3	±1.42		
		Negro	120	4.7	±1.42	2.373	<.02
Camp Drake Controls	White (U.S.) vs.		442	3.7	±1.62		
		Negro	60	4.6	±1.74	3.709	<.001
		Mongolian (Hawaii)	106	5.4	±1.73	9.412	<.001
		Hawaiian	22	5.7	±1.71	5.399	<.001
	Negro vs.		60	4.6	±1.74		
		Mongolian (Hawaii)	106	5.4	±1.78	2.861	<.01
		Hawaiian	22	5.7	±1.71	2.446	<.02
	Mongolian (Hawaii) vs.		106	5.4	±1.78		
		Hawaiian	22	5.7	±1.71	0.591	>.50

planation for this exception has to do with the small proportion of Negro controls from battalion level in contrast to White controls (Table 2). There was evidence (to be presented elsewhere in this section) that titers were higher among troops from forward combat areas than among rear echelon troops. Consequently, a higher mean initial titer might have been anticipated in the Negro group if the distribution with respect to forward and rear echelons had been comparable to the White group.

TABLE 2

RACIAL DISTRIBUTION OF THE R AND B CONTROL GROUPS ACCORDING TO COMBAT ECHELON

Combat Echelon	White		Negro	
	No.	%	No.	%
Army	332	23.3	88	51.2
Division	419	29.4	34	19.8
Regiment	401	28.1	42	24.4
Battalion	275	19.3	8	4.6
Total	1427	100.1	172	100.0

The difference between titers of White and Negro races, while distinct, was not large. Greater differences were noted in comparison of Whites with other racial groups. The apparent order of inherent cold hemagglutinating tendency (by increasing order of mean initial titer) was as follows:

Frostbite Patients	R and R Controls	Camp Drake Controls
White	White	White
Negro	Negro	Negro
*	Latin American	*
*	Mongolian	Mongolian (Hawaii)
*	*	Hawaiian

The data presented here indicated that cold hemagglutinin titers differed significantly among the various racial groups studied. The possibility that unrecognized diseases may account for these differences cannot be entirely excluded. The subjects studied were healthy troops, therefore the differences were considered a manifestation of racial characteristic. Because of the racial differences no analyses were made without first grouping data according to race.

2. Blood Groups

Limited data were collected for an analysis of the relationship between the blood group of a serum and its anti-O cold agglutinin content. The information as to blood group was taken from identification tags of 273 White soldiers of the R and R control group at the time the blood samples were collected. It should be pointed out that such data derived from identification tags may embody a 15% error (8). The distribution of these individuals according to blood groups approximated the expected normal (Table 3). The titer means followed

TABLE 3

DISTRIBUTION OF COLD HEMAGGLUTININ TITERS FOR
273 WHITE R AND E CONTROL SUBJECTS
ACCORDING TO BLOOD GROUPS

Blood Group	Observed No.	Incidence %	Mean Initial Titer	S. D.
O	134	49.1	3.1	±1.36
A	107	39.2	3.6	±1.42
B	19	7.0	3.6	±1.51
AB	13	4.8	3.8	±2.40
B+AB	32	0	3.7	±1.79

the sequence O, A, B and AB with O the lowest, A and B approximately equal and AB highest. Blood group differences should not influence the analyses presented in this investigation because the distribution of blood groups was assumed to remain constant as long as the racial distinction was made.

3. Age

A relationship has been found between age and titer of naturally occurring anti-A and anti-B agglutinins (9). Their studies indicated that these agglutinins are low at birth, increase to a peak about the time of puberty, and very gradually decline thereafter. The question arose as to whether any relationship to age holds also for the individual's normal cold hemagglutination tendency. The present investigation concerned soldiers within a narrow age range.

Data were available on the ages and titers of 240 frostbite patients (Table 4). The correlations between age

TABLE 4

CORRELATIONS BETWEEN THE AGE OF FROSTBITE PATIENTS AND THEIR MODAL TITERS

Race	No.	Factors	Avg.	Range	S. D.	r
White	122	Age (Yrs.) Modal Titer	22.3 4.2	18-38 1-8	±3.23 ±1.40	0.003
Negro	118	Age (Yrs.) Modal Titer	21.6 4.8	17-27 2-9	±1.94 ±1.40	0.152

and titer were not significant. It was concluded that in this investigation age difference had no significant bearing on cold hemagglutinin titers.

4. Cold Stress Studies

A substantial number of the frostbite patients was subjected, for purposes of a different investigation, to several 1 to 2 hour exposures (4 to 10) in ambient temperatures ranging between 35° and 60° F. It was important to know whether or not short exposures to cold could influence cold hemagglutination either by direct action or by indirect effect (increased incidence of upper respiratory infections). A comparison was made between the average modal titers of patients exposed and those who were not exposed (Table 5). The results showed that the average modal titer of the exposed and unexposed groups did not differ significantly. It was concluded that these brief repeated exposures of

TABLE 5

COMPARISONS OF AVERAGE MODAL COLD HEMAGGLUTININ
TITERS FOR FROSTBITE PATIENTS
WITH RESPECT TO COLD STRESS

Race	Group	No.	Avg. Modal Titer	S. D.	t	P
White	Exposed Unexposed	33 93	4.0 4.3	±1.34 ±1.46	0.858	>.30
Negro	Exposed Unexposed	37 83	4.8 4.8	±1.44 ±1.35	0.003	>.90

patients to cold had no appreciable effect on their cold hemagglutinin titers.

B. The Frostbite Group

1. Site of Injury

There might be reasons for a difference in the effect of cold hemagglutination in the pathogenesis of frostbite of the hands as compared to its influence on development of frostbite of the feet (differences in blood supply to the hands and feet). A comparison between average modal titers of patients with only frostbite of the hands and those with frostbite of the feet included 106 White patients and 106 Negro patients (Table 6). The differences in mean titers with respect to anatomical site of frostbite were not statistically significant in either White or Negro groups. Therefore, grouping data regardless of location of the lesions in subsequent analyses seemed

TABLE 6

COMPARISONS OF AVERAGE MODAL TITERS FOR FROSTBITE PATIENTS WITH RESPECT TO ANATOMICAL SITE OF INJURY

Race	Site of Injury	No.	Avg. Modal Titer	S. D.	t	P
White	Hand Foot	27 79	4.5 4.2	±1.63 ±1.34	1.015	>.30
Negro	Hand Foot	29 77	4.6 4.6	±1.37 ±1.48	0.094	>.90

justified.

2. Maximum Degree of Injury

Since it has been proposed that cold agglutinins might have some influence on the severity of tissue damage in frostbite, a demonstrable relationship might be anticipated between mean initial titer and maximum degree of injury. A comparison of mean titers according to various degrees of injury is shown in Tables 7 and 8. Because of the small number of fourth degree injuries, third and fourth degree patients were grouped together. In the White group differences in means were not significant. Larger differences in means were found in the Negro group, with the third-fourth degree groups having the highest mean titer, first degree next and second degree lowest. Therefore, analyses were made with respect to the degree of

TABLE 7

COMPARISONS OF COLD HEMAGGLUTININ TITERS FOR WHITE FROSTBITE PATIENTS ACCORDING TO MAXIMUM DEGREE OF INJURY

Maximum Degree of Injury	No.	Avg. Modal Titer	S. D.	t	P
First Second	34 56	4.1 4.4	±1.46 ±1.52	0.652	>.50
First Third and Fourth	34 36	4.1 4.3	±1.46 ±1.19	0.409	>.60
Second Third and Fourth	56 36	4.4 4.3	±1.52 ±1.19	0.279	>.70

agglutination within a given titer value. The difference between second degree and the third-fourth degree groups was the only one statistically significant. The results were consistent at all four levels of agglutination (Table 8). This peculiar relationship could not be explained.

A correlation between titers and degree of maximum injury for 126 White patients was not significant ($r = 0.028$). A similar correlation for 120 Negro patients was significantly different from zero ($r = 0.218$ $P < .05$) but was of too low an order to be important. This correlation was also consistent with low titers of second degree and high titers of third degree Negro patients and may have been the result of as yet

TABLE 8

COMPARISONS OF COLD HEMAGGLUTININ TITERS FOR NEGRO FROSTBITE PATIENTS WITH RESPECT TO TITER LEVEL AND MAXIMUM DEGREE OF INJURY

Degree of Agglutination	Maximum Degree of Injury	No.	Avg. Modal Titer	S. D.	$\bar{t}$	P
1+	First Second	16 46	4.6 4.2	±1.45 ±1.25	1.00	>.30
2+	First Second	16 46	3.0 2.9	±1.36 ±1.26	0.337	>.70
3+	First Second	16 46	1.7 1.3	±1.40 ±1.11	0.881	>.30
4+	First Second	16 46	0.8 0.4	±1.08 ±0.68	1.387	>.10
1+	First Third and Fourth	16 58	4.6 5.1	±1.45 ±1.44	1.210	>.20
2+	First Third and Fourth	16 58	3.0 3.4	±1.36 ±1.46	1.148	>.20
3+	First Third and Fourth	16 58	1.7 2.2	±1.40 ±1.33	1.276	>.20
4+	First Third and Fourth	16 58	0.8 0.9	±1.08 ±1.13	0.385	>.70
1+	Second Third and Fourth	46 58	4.2 5.1	±1.25 ±1.44	3.424	<.001
2+	Second Third and Fourth	46 58	2.9 3.4	±1.26 ±1.46	2.163	<.05
3+	Second Third and Fourth	46 58	1.3 2.2	±1.11 ±1.33	3.446	<.001
4+	Second Third and Fourth	46 58	0.4 0.9	±0.68 ±1.13	2.905	<.01

unrecognized factors rather than a distinct relationship between degree of injury and titers. Because of the lack of correlation in the White group and the low order of correlation in the Negro group, the severity of injury was also disregarded in subsequent grouping of

data for comparisons between frostbite and control groups.

3. Cause or Effect Relationship

Another purpose of this study was to prove or disprove the hypothesis that frostbite develops more readily in individuals possessing more potent cold hemagglutinins. In attempting to establish proof by comparison of titers from frostbite patients with those from an appropriate control group, an assumption had to be made that events leading to development of frostbite itself had no effect, direct or indirect, on the cold agglutinin titers of the patients. It was hoped that to substantiate this assumption, fortuitous selection of soldiers would have provided a series of results on the same individual both before and after frostbite. No such coincidence occurred. Therefore, any inference to be drawn on this question had to be based on a study of titer fluctuations during the first weeks following frostbite.

In Table 9 is a listing of patients (Group I) and their coded titer values obtained at weekly intervals post-injury. From visual inspection it is difficult to detect a trend in change of titers. An analysis was done by determining the rank order correlation between the initial titers of this group with each of the subsequent weekly set of readings. In the calculations only matched pairs of titer values were used, i.e., if in the fifth week only nine patients had titers performed then the nine corresponding

TABLE 9

TABULATION OF WEEKLY CODED TITER VALUES FOR 19 FROSTBITE PATIENTS UP TO 6 WEEKS POST-INJURY

Group I Patients	Coded Titer Values Following Injury Week 1	Week 2	Week 3	Week 4	Week 5
1	6	5	4	5	4
2	6	6	5	5	5
3	3	3	3	4	4
4	3	4	4	3	4
5	4	5	6	6	7
6	3	3	3	4	2
7	3	3	3	3	4
8	3	4	4	4	5
9	7	8	7	7	-
10	5	4	5	6	5
11	3	4	3	4	4
12	1	3	3	-	-
13	5	4	5	6	-
14	5	5	7	7	-
15	6	7	8	-	-
16	3	3	4	5	3
17	8	8	7	-	-
18	3	3	2	4	3
19	4	4	4	-	-

values for the first week were used for the correlations and "t" comparisons. The rho values were converted to "r" values and the "r" used in the comparison of titer means using the "t" test. The results for Group I are shown in Table 10. Included in the table are similar analyses for Groups II, III and IV on whom titers were first obtained during the second, third and fourth weeks post-frostbite respectively. The correlations between initial and subsequent titers were in all cases highly significant. The difference in the mean titers were in

TABLE 10

STATISTICAL COMPARISONS OF SERIAL MEAN TITERS FOR FROSTBITE PATIENTS OBTAINED FOR 6 CONSECUTIVE WEEKS POST-INJURY

Group	Week Post-injury	Mean Titer	Week Post-injury	Mean Titer	df	rho	Correlation r	Correlation P	Comparison t	Comparison P
I	1	4.3	2	4.5	36	0.896	0.903	<.01	1.471	>.10
	1	4.3	3	4.6	36	0.832	0.845	<.01	1.387	>.10
	1	4.1	4	4.9	28	0.815	0.829	<.01	3.438	<.01
	1	3.7	5	4.2	22	0.647	0.662	<.01	1.353	>.10
II	2	4.5	3	4.7	18	0.855	0.866	<.01	0.793	>.40
	2	4.5	4	4.7	18	0.839	0.851	<.01	0.691	>.50
III	3	4.6	4	5.5	32	0.583	0.601	<.01	2.516	<.02
	3	4.6	5	4.8	32	0.730	0.744	<.01	0.[illegible]72	>.50
IV	4	4.5	5	4.5	38	0.705	0.722	<.01	0.195	>.80
	4	4.5	6	4.2	38	0.733	0.749	<.01	1.116	>.20

a direction of an increase over the initial titers in every instance except the comparison between fourth and sixth weeks in Group IV. The differences were only statistically significant in the comparisons between the first and fourth weeks post-frostbite in Group I and between the third and fourth weeks in Group III.

An analysis of the relation of the weeks post-injury to titer values was then carried out. The weekly titer values for the 15 patients tested four consecutive weeks post-injury were correlated (Table 9). The correlation ($r = 0.184$) was not significant.

4. Constancy of Titers

Innumerable reports have appe[illegible]d in the literature attempting to relate cold agglutination to a host of

diseases. No criterion has been established on the occurrence and constancy of cold agglutinins in normal humans. It may be assumed that the cold hemagglutinins either remain basically constant, subject to minor fluctuations, or they appear and disappear rapidly in relation to various stimuli.

In a study of this problem 60 frostbite patients were selected regardless of race, degree of injury or time of initial titer after injury. The basis of selection was the requirement of at least six serial titer values at weekly intervals. The first six titers obtained after injury were used, and the titers numbered and grouped by the sequence one through six. By gross inspection no distinct or consistent changes could be detected except for minor fluctuations commensurate with the accuracy of the test. Statistical comparisons of each weekly group against the others are shown in Table 11. The correlations varying from 0.709 to 0.874 were all highly significant. In only two instances the difference in mean initial titer were statistically significant (second vs first and third weeks). The data indicated that no radical changes in titers occurred in this group of 60 frostbite patients subjected to similar living conditions for at least 6 weeks post-injury.

5. Conditions of Exposure

The possible relation of cold hemagglutination for cold

TABLE 11

STATISTICAL COMPARISONS OF CONSECUTIVE WEEKLY TITER VALUES OF 60 FROSTBITE PATIENTS

Weeks Compared		Mean Titer	S. D.	Correlation r	Correlation P	Comparison t	Comparison P
1 vs	-	4.7	± 1.45				
	2	4.4	± 1.48	0.79[illegible]	<.01	2.739	<.01
	3	4.6	± 1.53	0.7[illegible]9	<.01	0.454	>.60
	4	4.4	± 1.57	0.7[illegible]	<.01	1.[illegible]1	>.05
	5	4.6	± 1.44	0.7[illegible]	<.01	0.977	>.30
	6	4.4	± 1.61	0.7[illegible]	<.01	1.917	>.05
2 vs	-	4.4	± 1.48				
	3	4.6	± 1.53	0.7[illegible]	<.01	2.101	<.05
	4	4.4	± 1.57	0.[illegible]	<.01	0.6[illegible]9	>.50
	5	4.6	± 1.44	0.[illegible]	<.01	1.672	>.05
	6	4.4	± 1.61	0.7[illegible]3	<.01	0.592	>.40
3 vs	-	4.6	± 1.53				
	4	4.4	± 1.57	0.7[illegible]7	<.01	1.520	>.10
	5	4.6	± 1.44	0.[illegible]	<.01	0.5[illegible]9	>.60
	6	4.4	± 1.61	0.[illegible]	<.01	1.431	>.10
4 vs	-	4.4	± 1.57				
	5	4.6	± 1.44	0.[illegible]	<.01	1.[illegible]	>.20
	6	4.4	± 1.61	0.[illegible]5	<.01	0.147	>.80
5 vs	-	4.6	± 1.44				
	6	4.4	± 1.61	0.[illegible]7	<.01	1.052	>.20

injury might be indicated by correlating the cold hemagglutinin titer values for frostbite patients with certain etiologic factors such as: minimum temperature during cold exposure; average windchill during cold exposure and duration of the cold exposure. Detailed weather records of temperature, wind velocity, etc. were obtained from weather stations located across the front lines in Korea. The pertinent meteorological data were entered on each

Best Available Copy

patient's record. The minimum temperature was the lowest value recorded during the exposure period for the locale where the patient incurred frostbite. The windchill (10) values give a measure of the relative cooling effect of various combinations of temperature and wind velocity. The average windchill was calculated for the period and vicinity of exposure for each patient. The duration of exposure was the length of time that the patient was exposed to cold and incurred a frostbite injury.

The class intervals for the above factors are shown in Table 12 along with the respective correlations for White and Negro frostbite patients irrespective of degree of injury. The correlations were of zero order and consequently of no value as predictors. One of the windchill class intervals (less than 700) was too ambiguous to be included in the "r" calculation. Since a substantial proportion of the subjects was included in this interval, the distribution of titers of those patients exposed to an average windchill of less than 700 was compared with the distribution of those exposed to an average windchill greater than 700. There was no significant difference between these two distributions (Table 13). Similar correlations were performed between the titer values for patients with the greatest cold injury (third degree frostbite) according to minimum temperature and duration of the cold exposure. These correlations were also of zero order and consequently of no value as predictors (Table 14).

TABLE 12

SUMMARY OF CORRELATIONS BETWEEN COLD HEMAGGLUTININ TITERS FOR WHITE AND NEGRO FROSTBITE PATIENTS AND CERTAIN ETIOLOGIC FACTORS

Class Intervals	Minimum Temperature (Degrees Fahrenheit)		Average Windchill (Kg. cal/M²/Hr.)		Duration of Exposure (Hours)	
	- 11 to - 5				0 to 4	
	- 4 to 2		700 to 824		4.1 to 8	
	3 to 9		825 to 949		8.1 to 12	
	10 to 16		950 to 1074		12.1 to 16	
	17 to 23		1075 to 1199		16.1 to 24	
	24 to 37		1200 to 1324		24.1 to 48	
					48.1 to 72	
Race	No.	r	No.	r	No.	r
White	118	0.023	81	0.027	119	0.120
Negro	[illegible]	0.053	72		117	0.053

TABLE 13

FREQUENCY DISTRIBUTION OF CODED TITERS FOR FROSTBITE PATIENTS EXPOSED TO TWO GENERAL CATEGORIES OF WIND CHILL

Race	Average Windchill	N	Coded Titer Value 0	1	2	3	4	5	6	7	8	9	Chi Square	P
White	<700	31	0	0	2	7	9	8	3	1	1	0	1.308	>.99
	>700	[illegible]	0	1	7	19	17	23	9	2	3	0		
Negro	<700	26	0	0	1	3	9	6	6	0	0	1	8.023	>.30
	>700	72	0	0	2	14	14	19	15	5	2	0		

In these analyses no relationship could be found between the patients' cold hemagglutinin titers and certain components of cold which were partially responsible for frostbite in each instance. This does not disprove that proneness to frostbite is a function of the cold hemagglutinin concentration, but merely points out that cold

TABLE 14

CORRELATIONS BETWEEN THE COLD HEMAGGLUTININ TITERS FOR 76 THIRD DEGREE FROSTBITE PATIENTS AND CERTAIN WEATHER FACTORS

Race	Minimum Temperature During Exposure		Duration of Exposure	
	No.	r	No.	r
White	33	0.136	33	0.020
Negro	43	0.007	49	- 0.041

hemagglutination is probably not an important factor in frostbite susceptibility.

C. The Control Groups

1. R and R Controls

An analysis was made to determine the variability of cold hemagglutination for the different sources from which the R and R control population was derived, namely: Eighth Army support troops, divisional support troops, regimental support troops and infantry battalion troops. Additional analyses were performed in which comparisons between Eighth Army support troops and infantry division troops as well as inter-divisional comparisons were made.

In the first analysis (Table 15) there were significant differences between mean titers of White individuals for the different combat echelons. There was a progressive increase in the mean titers from the Eighth Army support through the various echelons to the infantry battalion troops. A similar trend was suggested in the Negro group, although the difference between the means was not significant.

TABLE 15

COMPARISONS OF MEAN COLD HEMAGGLUTININ TITERS FOR
R AND R CONTROLS ACCORDING TO THEIR COMBAT ECHELON

Race	Combat Echelon Comparisons		No.	Mean Initial Titer	S. D.	t	P
White	8th Army vs		332	3.0	± 1.57		
		Division	419	3.1	± 1.39	0.473	>.60
		Regiment	401	3.6	± 1.49	4.606	<.001
		Battalion	275	3.8	± 1.70	5.657	<.001
	Division vs		419	3.1	± 1.39		
		Regiment	401	3.6	± 1.49	4.712	<.001
		Battalion	275	3.8	± 1.70	5.754	<.001
	Regiment vs		401	3.6	± 1.49		
		Battalion	275	3.8	± 1.70	1.822	>.05
Negro	8th Army vs		88	3.4	± 1.47		
		Division	34	3.6	± 1.91	0.698	>.40
		Regiment	42	4.0	± 1.79	1.822	>.05
	Division vs		34	3.6	± 1.91		
		Regiment	42	4.0	± 1.79	0.768	>.40

The comparisons between the Eighth Army support troops and divisions as well as the inter-divisional analyses utilized only White subjects since the small Negro population made the multiple breakdown statistically inadequate. The results (Tables 16 and 17) showed high mean titers for two divisions, the 40th and 45th. The mean of the 45th Division was significantly higher than that of Eighth Army and all divisions except the 40th. The mean of the latter was also significantly higher than Eighth Army, the 7th and 25th Divisions but not in any other case. The means of the remaining divisions did not differ significantly from one another.

TABLE 16

COMPARISONS BETWEEN MEAN TITERS OF WHITE TROOPS FROM EIGHTH ARMY SUPPORT AND DIVISIONS

Comparison of 8th Army to Divisions		No.	Mean Initial Titer	S. D.	t	P
8th Army vs		332	3.0	± 1.57		
	2nd	242	3.4	± 1.55	2.946	<.01
	3rd	60	3.4	± 1.47	1.692	>.05
	7th	145	3.2	± 1.32	1.235	>.20
	25th	262	3.2	± 1.55	1.074	>.20
	40th	221	3.7	± [illegible]	[illegible]	<.001
	45th	150	3.9	± 1.75	[illegible]	<.001

TABLE 17

INTER-DIVISIONAL COMPARISONS OF MEAN TITERS FOR WHITE R AND R CONTROLS

Division Comparisons		No.	Mean Initial Titer	S. D.	t	P
2nd vs		242	3.4	± 1.56		
	3rd	[illegible]	3.4	[illegible]	[illegible]	>.60
	7th	[illegible]	3.2	[illegible]	[illegible]	>.10
	25th	[illegible]	3.2	[illegible]	[illegible]	>.05
	40th	[illegible]	3.7	[illegible]	[illegible]	>.05
	45th	[illegible]	3.9	[illegible]	[illegible]	<.02
3rd vs		60	3.4	± [illegible]		
	7th	[illegible]	3.2	[illegible]	[illegible]	[illegible]
	25th	[illegible]	3.2	[illegible]	[illegible]	[illegible]
	40th	221	3.7	[illegible]	[illegible]	>.05
	45th	150	3.9	± 1.75	[illegible]	<.05
7th vs		[illegible]	3.2	± 1.32		
	25th	[illegible]	3.2	[illegible]	[illegible]	>.80
	40th	[illegible]	3.7	± 1.39	3.215	<.01
	45th	[illegible]	3.9	± 1.75	3.552	<.001
25th vs		[illegible]	3.2	± 1.56		
	40th	[illegible]	3.7	[illegible]	[illegible]	<.001
	45th	[illegible]	3.9	[illegible]	[illegible]	<.001
40th vs		221	3.7	± 1.39		
	45th	150	3.9	± 1.75	[illegible]	>.20

It was concluded that the 1,432 White control sera obtained from soldiers stationed in Korea did not represent a sample from a homogeneous group. The evidence suggested that either single or multiple unknown factors tended to modify the titers and that these factors possibly were related to the combat echelon of the soldiers.

2. Camp Drake Controls

Further evidence of a climatic influence on cold hemagglutinin titers was suggested by results obtained from soldiers arriving in Japan from the United States and Hawaii. Presumably these soldiers had been subjected to milder weather conditions than the soldiers stationed in Korea. No details were obtained concerning the medical history of these troops. The soldiers from Hawaii had been there a minimum of 6 months prior to arrival in Japan. The mean titer values for the White and Negro groups direct from the United States were significantly higher than those of R and R controls (Table 18). The White soldiers from Hawaii had a higher mean titer than any of the other White groups. The Mongolian group from Hawaii had a higher mean initial titer than did the R and R Mongolian group, but the difference was not statistically significant. A trend of higher titer values among troops from warmer climates was consistent in all racial groups.

D. Climatic Region of Native State

The preceding analyses suggested a variation in titers with respect to the race and climatic environment of the subjects.

TABLE 18

RACIAL COMPARISONS BETWEEN COLD HEMAGGLUTININ TITERS OF R AND R AND CAMP DRAKE CONTROL GROUPS

Control Group: R and R	Control Group: Camp Drake	No.	Mean Initial Titer	S. D.	t	P
White vs		1432	3.4	± 1.55		
	White(U.S.)	442	3.7	± 1.62	3.554	<.001
	White(Hawaii)	45	4.3	± 1.91	3.320	<.001
	White(U.S.)vs	442	3.7	± 1.62	2.187	<.05
	White(Hawaii)	45	4.3	± 1.91		
Negro vs		172	3.6	± 1.66	3.988	<.001
	Negro(U.S.)	60	4.6	± 1.74		
Mongolian vs		20	4.5	± 1.98	1.879	>.05
	Mongolian (Hawaii)	106	5.4	± 1.78		

It might be inferred that adaptation to climatic environment over a long period of time resulted in these cold hemagglutinin differences. Evidence of a more immediate but permanent climatic influence on titers was sought by studying the incidence of cold hemagglutinin titers of United States Whites and Negroes according to the climatic region in which they had lived most of their lives. Information was obtained from each frostbite patient as to the state in which he spent the major part of his life. The states were grouped according to Orr's and Fainer's method (11) into four general climatic regions on the basis of the average minimum temperatures for January, as shown below:

Region I, less than 10° F.
Region II, 10.1° to 20° F.
Region III, 20.1° to 35° F.
Region IV, over 35° F.

Because of incomplete data the analyses were limited to comparisons of 117 White patients representing Regions II, III and IV, and 109 Negro patients from Regions III and IV (Table 19). There were no cases from Region I. The differences in titer values for the patients from the different regions were small and statistically not significant. There was no evidence that the climatic regions in the United States from which the patients originated had a lasting effect on cold hemagglutinin titers.

E. Frequency Distribution Curves

From the titer values and standard deviations theoretical normal frequency curves were determined (maximum ordinate method) for the different groups of subjects. The observed frequencies were then compared with theoretical frequencies by chi square to determine the fit of each distribution with its theoretical normal distribution (Table 20). The description of the fit was based on the "P" according to the interpretation suggested by Culler (12).

TABLE 19

COMPARISON OF MEAN TITERS FOR FROSTBITE PATIENTS ACCORDING TO CLIMATIC REGION OF NATIVE STATE

Race	Climatic Region Comparison		No.	Avg. Modal Titer	S. D.	t	P
White	II vs		28	4.2	± 1.63		
		III	49	4.2	± 1.50	0.231	>.80
		IV	40	4.3	± 1.22	0.0[illegible]9	>.90
	III vs		49	4.2	± 1.50	0.386	>.70
		IV	40	4.3	± 1.22		
Negro	III vs		54	4.7	± 1.43	0.418	>.60
		IV	55	4.8	± 1.45		

TABLE 20

FREQUENCY DISTRIBUTION OF COLD HEMAGGLUTININ TITERS FOR THE POPULATIONS STUDIED

Race	Groups	Observed Frequency Distributions (Titers and Coded Values) Neg. 0	1:2 1	1:4 2	1:8 3	1:16 4	1:32 5	1:64 6	1:128 7	1:256 8	1:512* 9**	No.	Mean Initial Titer	S. D.
White	R and R Controls	[illegible]	118	324	349	292	208	[illegible]	31	2	5	1432	3.4	± 1.55
	R and R Control: 8th Army	6	48	85	77	48	45	16	6	1	0	332	3.0	± 1.57
	R and R Control: Division	7	32	120	113	70	55	19	2	0	0	419	3.1	± 1.39
	R and R Control: Regiment	4	20	72	110	93	62	26	12	1	1	401	3.6	± 1.49
	R and R Control: Battalion	2	18	46	46	81	44	23	11	0	4	275	3.8	± 1.70
	Camp Drake: United States	4	28	83	87	116	73	30	17	0	4	442	3.7	± 1.62
	Camp Drake: Hawaii	0	3	4	7	15	6	3	3	3	1	45	4.3	± 1.91
	Frostbite Patients	0	2	9	28	32	34	14	3	4	0	126	4.3	± 1.42
	Frostbite Patients (Inf. Bn.)	0	2	7	19	28	28	11	2	3	0	100	4.3	± 1.39
Negro	R and R Controls	4	9	33	39	41	25	12	6	2	1	172	3.6	± 1.66
	R and R (Regiment)	2	2	2	10	13	4	5	3	1	0	42	4.0	± 1.79
	Camp Drake United States	0	1	4	13	11	12	13	3	1	2	60	4.6	± 1.74
	Frostbite Patients	0	0	3	25	29	27	23	10	2	1	120	4.7	± 1.42
	Frostbite Patients (Inf. Bn.)	0	0	3	19	21	22	17	8	2	1	93	4.7	± 1.47
Mongolian (Hawaii)		0	1	1	9	24	22	21	19	4	5	106	5.4	± 1.78
Hawaiian		0	0	0	2	3	5	4	5	1	1	22	5.7	± 1.71

* 1:512 or Over
** 9 or Over

The distributions of the R and R control group as a whole, the Eighth Army support and the division support from the R and R control groups were shown not to be normally distributed (Table 21). The fit of the White Camp Drake controls from the United States was also poor. It was in these groups that one might expect the greatest heterogeneity from the standpoint of theoretical climatic influence on titers. Titers of those groups in which the greatest homogeneity was anticipated, such as the frostbite casualties from infantry battalions and the control group from Hawaii, were normally distributed.

TABLE 21

CHI SQUARE OF THE GOODNESS OF FIT FOR COLD HEMAGGLUTININ TITER DISTRIBUTIONS TO THE THEORETICAL NORMAL ON THE POPULATIONS STUDIED

Race		Groups	Comparison to Theoretical Normal Distribution: Chi Square	df	P	Fit
White		R and R Controls	37.724	7	<.001	Unacceptable
White	Camp R and R Control	8th Army	23.654	7	<.01	Unacceptable
White	Camp R and R Control	Division	25.239	6	<.001	Unacceptable
White	Camp R and R Control	Regiment	8.666	7	>.25	Good
White	Camp R and R Control	Battalion	13.194	8	>.10	Medium
White	Camp Drake Control	United States	13.613	7	>.05	Poor
White	Camp Drake Control	Hawaii	8.593	8	>.30	Good
White		Frostbite Patients	2.169	7	>.90	Superlative
White		Frostbite Patients (Inf. Bn.)	0.836	7	>.99	Superlative
Negro		R and R Controls	4.913	7	>.50	Excellent
Negro		R and R (Regiment)	6.304	8	>.50	Excellent
Negro		Camp Drake (United States)	4.946	9	>.80	Superlative
Negro		Frostbite Patients	7.804	7	>.30	Good
Negro		Frostbite Patients (Inf. Bn.)	4.146	7	>.70	Superlative
Mongolian (Hawaii)			7.438	10	>.50	Excellent
Hawaiian			1.240	8	>.99	Superlative

F. Frostbite Group vs Control Groups

Since no consistent difference in titers could be related to site or severity of injury, the initial titers of frostbite patients were grouped except for a distinction between the races. Because the sampling from races other than White and United States Negro was totally inadequate for analysis, the other racial groups were not analyzed.

The initial mean titer comparisons are presented in Tables 22, 23 and 24 between frostbite patients and different control groups. The comparison between R and R controls and frostbite patients (Table 22) shows a significant difference in the mean titer values at all agglutination levels except 4 + in the White groups. It has been shown that there was lack of homogeneity in the R and R control group which appeared to be related in some way to the combat echelon. A majority of the frostbite victims (White 79.4%, Negro 77.50%) came from infantry battalions whereas a minority of the control group (White 19.2%, Negro 4.7%) originated from this echelon. Since titer values were highest in infantry battalion controls, it was apparent that biased sampling could have contributed greatly to the significant titer differences between the frostbite and control groups.

In the second analysis (Table 23) only infantry battalion soldiers of the frostbite group were compared with control subjects of the corresponding unit. In the Negro control group, however, there was an inadequate number of infantry battalion soldiers so that the regimental support subjects

TABLE 22

COMPARISONS BETWEEN FROSTBITE AND R AND R CONTROL SUBJECTS ACCORDING TO DEGREE OF AGGLUTINATION AND CORRESPONDING MEAN TITER

Race	Degree of Agglutination	Group	No.	Mean Initial Titer	Standard Deviation	t	P
White	1+	Frostbite	126	4.3	± 1.42	6.920	<.001
		Control	1432	3.4	± 1.55		
	2+	Frostbite	126	2.7	± 1.45	4.517	<.001
		Control	1432	2.1	± 1.50		
	3+	Frostbite	126	1.5	± 1.37	3.512	<.001
		Control	1432	1.0	± 1.25		
	4+	Frostbite	126	0.5	± 0.97	1.542	>.10
		Control	1432	0.4	± 0.77		
Negro	1+	Frostbite	120	4.7	± 1.42	6.084	<.001
		Control	172	3.6	± 1.66		
	2+	Frostbite	120	3.2	± 1.39	5.498	<.001
		Control	172	2.2	± 1.58		
	3+	Frostbite	120	1.8	± 1.33	4.312	<.001
		Control	172	1.1	± 1.31		
	4+	Frostbite	120	0.7	± 0.99	2.679	<.01
		Control	172	0.4	± 0.79		

TABLE 23

COMPARISON BETWEEN FROSTBITE PATIENTS OF BATTALION LEVEL AND R AND R CONTROLS (WHITE CONTROLS FROM BATTALIONS. NEGRO CONTROLS FROM REGIMENTAL LEVEL)

Race	Degree of Agglutination	Group	No.	Mean Initial Titer	Standard Deviation	t	P
White	1+	Frostbite	100	4.3	± 1.39	2.787	<.01
		Control	275	3.6	± 1.70		
	2+	Frostbite	100	2.7	± 1.43	0.724	>.40
		Control	275	2.5	± 1.66		
	3+	Frostbite	100	1.5	± 1.31	0.329	>.70
		Control	275	1.4	± 1.45		
	4+	Frostbite	100	0.5	± 0.88	1.099	>.20
		Control	275	0.6	± 0.97		
Negro	1+	Frostbite	93	4.7	± 1.47	2.391	<.02
		Control	42	4.0	± 1.79		
	2+	Frostbite	93	3.2	± 1.43	1.681	>.05
		Control	42	2.7	± 1.74		
	3+	Frostbite	93	1.8	± 1.34	1.461	>.10
		Control	42	1.5	± 1.40		
	4+	Frostbite	93	0.7	± 1.02	0.467	>.60
		Control	42	0.6	± 1.02		

were included for the comparison with Negro battalion frostbite casualties. The titers of the frostbite groups, both White and Negro, were significantly higher than the control groups only at the 1+ agglutination level.

A comparison also was made between the frostbite group and the Camp Drake control group (Table 24). The White frostbite patients had significantly higher titers at the 1+ agglutination level but not at the 2+, 3+ or 4+ levels. The Negro frostbite group had lower titers at all agglutination levels with the difference becoming significant at the 4+ level.

Throughout the analyses a low incidence of negative, 1:2 and 1:4 titers was noted in the frostbite group as compared to the control groups. The distribution of 1+ titers of the two groups might be described generally as having the same upper limit (1:256) but with lower limits differing. The kurtosis (measure of flatness) of the frostbite curves was greater and the distribution did not contain as many low titers in the frostbite group as did the control group. This difference in distributions were also reflected in the standard deviations, which were smaller (1.3-1.4) for the frostbite groups, than (1.6-1.7) for the control groups.

To pursue further the apparent importance of a difference in weak titers, an analysis was made of the first tube agglutinations. Physiologically, interest should actually center on the agglutinating capacity of sera in the undiluted state since dilution would most likely not be a factor in intravascular agglutination. Comparisons were made of distribution

of 0, 1+, 2+, 3+ and 4+ first tube agglutinations of frostbite and control groups by chi square (1+ and 2+ agglutinations classified as weak and 3+ and 4+ agglutinations as strong). In every instance the distributions differed significantly except for the comparison of White infantry battalion soldiers (Table 25). Those points which contributed to the significant chi square values were also determined. In four of the six comparisons there were significant differences in the incidence of 1+ first tube agglutinations as the result of being significantly low in the frostbite group and/or significantly high in control group.

From these analyses it would appear that weak agglutinations were less frequent among frostbite casualties than would have been anticipated had the patients and controls represented separate sample groups from the same universe. The differences between frostbite and control groups were not great, particularly when consideration was given to a possible influence of environmental conditions on the titers of any one group studied. If one conjectures that cold hemagglutinins contribute to frostbite susceptibility the statistical evidence just presented indicated that soldiers with titers 1:4 or less were perhaps more resistant to the effects of cold, namely, frostbite. There was no consistent evidence that titer differences beyond the 1:4 level had any appreciable bearing on frostbite susceptibility.

C. Thermal Amplitudes

Thermal amplitude (3) refers to the thermal range in which the activity of an antibody may be demonstrated. In a limited

TABLE 24

COMPARISONS BETWEEN FROSTBITE AND CAMP DRAKE CONTROLS ACCORDING TO DEGREE OF AGGLUTINATION AND CORRESPONDING MEAN TITER

Race	Degree of Agglutination	Group	No.	Mean Initial Titer	S. D.	t	P
White	1+	Frostbite Control	126 442	4.3 3.7	± 1.42 ± 1.62	4.124	<.001
	2+	Frostbite Control	126 442	2.7 2.4	± 1.45 ± 1.63	1.549	>.10
	3+	Frostbite Control	126 442	1.5 1.5	± 1.37 ± 1.45	0.186	>.80
	4+	Frostbite Control	126 442	0.5 0.7	± 0.97 ± 1.01	1.452	>.10
Negro	1+	Frostbite Control	120 60	4.7 4.6	± 1.42 ± 1.74	0.289	>.70
	2+	Frostbite Control	120 60	3.2 3.3	± 1.39 ± 1.74	0.710	>.40
	3+	Frostbite Control	120 60	1.8 2.2	± 1.33 ± 1.64	1.844	>.05
	4+	Frostbite Control	120 60	0.7 1.3	± 0.99 ± 1.24	3.254	<.01

TABLE 25

COMPARISON BETWEEN ANALOGOUS FROSTBITE AND CONTROL GROUPS IN ACCORDANCE WITH STRENGTH OF THE FIRST TUBE AGGLUTINATION

	Groups Compared	Degree of Agglutination						Chi Square	P
		No.	0	1+	2+	3+	4+		
White	Frostbite R and R Control	126 1432	0 19	4 150	33 473	51 404	38 341	20.295	<.001
	Frostbite (Inf.Bn.) R and R Control (Infantry Bn.)	100 275	0 2	4 28	24 68	42 77	30 100	9.355	>.05
	Frostbite Camp Drake (From United States)	126 442	0 4	4 45	33 95	51 130	38 168	12.210	<.02
Negro	Frostbite R and R Controls	120 172	0 4	0 18	19 55	49 47	52 48	31.364	<.001
	Frostbite (Inf.Bn.) R and R Control (Regiment)	93 42	0 2	0 3	15 9	37 13	41 15	13.057	<.02
	Frostbite Camp Drake (From United States)	120 60	0 0	0 2	19 8	49 11	52 39	13.698	<.01

study of thermal amplitudes of cold hemagglutinins, sera R and R controls with titers of 1:64 or higher were selected as those most likely to show the highest thermal amplitudes. After 16 hours of refrigeration and initial readings of the tubes in the 0° C. walk-in refrigerator, the titration mixtures were placed immediately in another walk-in refrigerator (10° C.) for a minimum of 16 hours and the titers then reread. In Group I the titration mixtures after being refrigerated and read at 0° C. were rewarmed by exposure to room temperature for approximately 3 hours in order to reverse the agglutinations. These mixtures, rewarmed and resuspended by agitation, were again immediately refrigerated for 16 hours and reread at 10° C. In Group II the titer tubes after being refrigerated and read were transferred directly from 0° to 10° C. eliminating the rewarming phase. In both groups the 10° titer values were consistently lower with the differences being statistically significant at all agglutination levels (Tables 26, 27). The correlation between the 0° and 10° titer was not significant at the 1+ agglutination level. Greater decrease in the 10° titer values was apparent when rewarming was permitted between the 0° and 10° refrigeration periods. Analyses in Table 28 show comparisons between the initial titer value for Groups I and II prior to transfer. The differences in the means did not exceed 0.4 tubes in the 0° C. tests with the only significant difference being at the 1+ agglutination level. The difference between the two groups was greater in the 10° C. tests and highly significant at

TABLE 26

LISTING OF TITER VALUES ACCORDING TO VARIATIONS IN REFRIGERATION TEMPERATURES

GROUP I			GROUP II		
Sample No.	Titers Read at 0° C.	Titers Read at 10° C. after Rewarming	Sample No.	Titers Read at 0° C.	Titers Read at 10° C. No Rewarming
1	1:512	1:4	1	1:64	1:16
2	1:64	1:4	2	1:128	1:16
3	1:256	1:8	3	1:64	1:16
4	1:512	1:4	4	1:64	1:32
5	1:64	1:8	5	1:128	1:16
6	1:64	1:16	6	1:64	1:16
7	1:128	1:4	7	1:64	1:16
8	1:512	1:8	8	1:128	1:16
9	1:128	1:2	9	1:64	1:8
10	1:512	1:2	10	1:64	1:16
11	1:128	0	11	1:128	1:16
12	1:64	1:4	12	1:128	1:16
13	1:64	1:2	13	1:64	1:16
14	1:128	1:4	14	1:64	1:8
15	1:128	1:2	15	1:128	1:16
16	1:64	1:2	16	1:64	1:8
17	1:128	1:2	17	1:128	1:8
18	1:64	1:2	18	1:64	1:16
19	1:64	0	19	1:64	1:16
20	1:64	0	20	1:128	1:16
21	1:64	1:4	21	1:64	1:32
22	1:128	1:2	22	1:64	1:16
23	1:64	1:4	23	1:128	1:16
24	1:64	1:4	24	1:64	1:16
25	1:128	1:8	25	1:64	1:16
26	1:64	1:4	26	1:64	1:16
27	1:64	1:2	27	1:64	1:32
28	1:64	1:4	28	1:64	1:16
29	1:64	1:2			
30	1:64	1:0			
31	1:128	1:2			
32	1:128	1:2			
33	1:64	1:2			
34	1:64	1:4			
35	1:128	1:2			
36	1:128	1:2			
37	1:64	1:4			
38	1:64	1:2			
39	1:128	1:4			

TABLE 27

COMPARISONS BETWEEN COLD HEMAGGLUTININ TITERS READ AT 0° AND 10° C.

Group	Degree of Agglutination	Reading Temperature	No.	Mean Titer	S. D.	t	P	r
Group I Agglutinations Reversed Between Readings	1+	0° C. 10° C.	39 39	6.7 1.5	± 0.94 ± 0.90	24.830	<.001	0.187
	2+	0° C. 10° C.	39 39	4.7 0.3	± 0.88 ± 0.52	26.579	<.001	-
	3+	0° C. 10° C.	39 39	3.2 0.0	± 0.89 ± 0.00	22.085	<.001	-
	4+	0° C. 10° C.	39 39	1.8 0.0	± 1.03 ± 0.00	11.000	<.001	-
Group II Agglutinations Not Reversed Between Readings	1+	0° C. 10° C.	28 28	6.3 4.1	± 0.48 ± 0.75	13.118	<.001	0.207
	2+	0° C. 10° C.	28 28	4.7 2.5	± 0.90 ± 1.09	8.408	<.001	-
	3+	0° C. 10° C.	28 28	3.5 1.4	± 1.19 ± 1.04	7.036	<.001	-
	4+	0° C. 10° C.	28 28	2.2 0.5	± 1.04 ± 0.71	7.068	<.001	-

TABLE 28

COMPARISONS BETWEEN COLD HEMAGGLUTININ TITERS READ AT 0° AND 10° C. ACCORDING TO DEGREE OF AGGLUTINATION

Reading Temperature	Degree of Agglutination	Group	No.	Mean Titer	S. D.	t	P
Readings at 0° C.	1+	I II	39 28	6.7 6.3	± 0.94 ± 0.48	2.106	<.05
	2+	I II	39 28	4.7 4.7	± 0.88 ± 0.90	0.261	>.70
	3+	I II	39 28	3.2 3.5	± 0.89 ± 1.19	1.164	>.10
	4+	I II	39 28	1.8 2.2	± 1.03 ± 1.04	1.394	>.10
Readings at 10° C.	1+	I II	39 28	1.5 4.1	± 0.90 ± 0.75	12.811	<.001
	2+	I II	39 28	0.3 2.5	± 0.52 ± 1.09	9.738	<.001
	3+	I II	39 28	0.0 1.4	± 0.00 ± 1.04	6.871	<.001
	4+	I II	39 28	0.0 0.5	± 0.00 ± 0.71	3.748	<.001

all agglutination levels.

These studies indicated that the agglutinations formed at 0° C. were more stable when the titration mixtures were transferred directly to a 10° C. environment without rewarming even though the subsequent readings were significantly lower. The agglutinations which developed at 10° C. following rewarming, however, were weaker even though sera with a good hemagglutinating potential (1:64) had been selected for the test. The relative weakness of agglutination in the latter instance is better illustrated by analyses of the strengths of first tube agglutinations (Table 29). The distributions of first tube readings at 0° C. of the two groups were closely similar. Highly significant differences were evident in comparison to 10° C. readings in that much weaker first tube agglutinations were present in the Group I sera.

TABLE 29

COMPARISONS BETWEEN COLD HEMAGGLUTININ TITER READ AT 0° AND 10° C. IN ACCORDANCE WITH FIRST TUBE AGGLUTINATION

Reading Temperature	Group	No.	First Tube Agglutination: Neg.	1+	2+	3+	4+	Chi Square	P
0° C.	I	39	0	0	0	4	35	1.678	>.70
	II	28	0	0	1	2	25		
10° C.	I	39	4	23	12	0	0	7.055	<.001
	II	28	0	2	4	11	11		

IV. DISCUSSION

The incidence of cold hemagglutination found in this investigation pointed to the desirability of seeking criteria for distinguishing, if possible, between cold hemagglutinin which occurs as

a natural phenomenon and that which results from pathological alteration. Rosenthal and Corten (3) attempted such a differentiation and suggested that pathologic cold hemagglutinin represents something beyond a mere increase in amount of normal cold hemagglutinin. Stats and Wasserman (3) in reviewing this question, however, concluded that "except for a general tendency to higher titers and broader thermal amplitudes of the cold hemagglutinin in pathologic sera, there is no demonstrable difference between such cold agglutinins and those in normal sera".

Race is perhaps the most distinct characteristic influencing cold hemagglutination titer expectation in any individual. The conclusion that cold hemagglutinin titers were higher in Negro than in White individuals was indicated by Weiner (1). Fetterman, Moran and Hess (13) had previously found unexpectedly high cold hemagglutinin levels among native Melanesians of a South Pacific island. They suggested that this finding might have been due either to some disease endemic in the area or to a racial characteristic.

The suggestion of Stats and Wasserman (3) seems reasonable that the presence of cold hemagglutinins, pathologic with respect to their cause, would best be judged by demonstration of radical change in titer from that usually observed in the individual. Such a criterion would assume that cold hemagglutinin titers normally remain fairly constant in each individual. No reports could be found in the literature regarding the constancy of titers. The statements reported here regarding this question are in agreement with the experience throughout the investigation that titers remained remarkably constant.

Kreyberg (14) refers to man as the "tropical animal" because of his preference for warm environment and his difficulty in adapting to

cold. In comparing man's vascular reaction to prolonged cooling with the reactions of certain other animal types he states: "The cold-blooded frog, adapted to stand low temperatures as a part of its normal life will show small changes and slight reactions. Man . . . . . will show violent reactions to exposure to cold, and the rabbit, fur-coated and used to cold and wet grounds, shows a reaction of intermediate type".

It may be more than coincidental that there is an analogous relationship between cold hemagglutination tendencies of frogs (which apparently have not been studied), rabbits which have cold hemagglutinins in at least some instances (3) and man who has a comparatively strong cold hemagglutinating tendency. The normal occurrence of cold hemagglutinins would be incompatible with the existence of the frog as a "cold-blooded" animal, whereas it is compatible with man's being "warm-blooded". Therefore, in an investigation of the relationship between frostbite and cold hemagglutination in healthy individuals, interest centers on the possibility that normally occurring cold hemagglutinins, usually compatible with good health in the individual might assume pathological importance when the individual's environment is changed to one of extreme cold.

The effect of environment on cold hemagglutination was in part answered by the comparison of mean titers of subjects between combat echelons and infantry divisions and duration of time the individuals had been stationed in Korea. This analogy was suggested by the fact that the 40th and 45th Divisions were the newest to the Korean theater (having arrived in December and January), while the Eighth Army troops had been in Korea the longest (since they were rotated the slowest).

If there was a relationship between cold hemagglutination titers and duration of duty in Korea, such a relationship would have been inverse, that is, the longer the stay in Korea, the lower the titer. This was found to be true (Tables 15, 16, 17).

A theory may be proposed that repeated exposures to cold weather might over a period of time have caused absorption and destruction of cold hemagglutinin and resulted in a minor reduction of titer in each individual exposed. If similar reductions were to occur in all individuals of a group the difference would become significant. A slight rise in titer then would be expected with a return of warm weather or removal of the individual to a warmer environment. In this way climatic conditions might act as a factor in the control of equilibrium between production and destruction of cold hemagglutinin.

Two ways in which tissue may become damaged as a result of exposure to cold are recognized (14). First, there is probably a direct injury to the tissues from extreme cold sufficient to kill the cells. Secondly, a vascular reaction (constriction) may cause further and fatal injury to cells in instances where the severity of cooling per se was not sufficient to cause irreparable damage. A pathogenetic effect of cold hemagglutinins would be associated with the vascular reaction. The issue of their importance in any case of cold injury would clearly be dependent on the relationship between extent of local cooling and thermal amplitudes of the individual's cold hemagglutinins.

One of the characteristics regarding cold hemagglutination among apparently healthy individuals reported by some authors is that of wide thermal amplitude extending to room temperature (3). Of over 11,000 blood samples tested during this investigation, however, no sera were

encountered which were capable either of autoagglutination or of agglutinating Group O erythrocytes at room temperature, even though titers at 0° C. ranged as high as 1:2048 and one titer was 1:8192. The majority of these sera were obtained from healthy troops and the only disease with appreciable incidence was frostbite.

Stats and Wasserman (3) cited the following conflicting views of different authors regarding thermal amplitudes of cold hemagglutinins in humans:

1) Mino and Kettel believed that thermal amplitudes are related and approximately proportional to titers.
2) Hirszfeld stated that thermal amplitude is not only a question of the titer but of the affinity of the normal antibodies.
3) Thompsen agreed with Hirszfeld in the belief that thermal amplitude is a constitution . characteristic and by itself of no pathological significance.

In the studies of thermal amplitudes in the present report it was found that even the more potent "normal" cold hemagglutinins had a relatively narrow thermal amplitude. Sera capable of agglutination to a dilution of 1:64 or higher at 0° C. agglutinated only weakly when exposed to 10° C. for 16 hours. It was found, however, that if the temperature of titrations with strong cold agglutination formed at 0° C. was raised to 10° C. a stronger agglutination persisted than that anticipated if the agglutination developed at 10° C. This finding was in keeping with the results obtained by Clough and Richter (15) from studies of a cold hemagglutinin with high thermal amplitude, in which the authors showed that agglutination persisted at a temperature higher

than was necessary for its initiation. A practical implication of this finding is that if frostbitten parts are allowed to rewarm too gradually, circulatory stasis might be prolonged by persistence of intravascular cold hemagglutination, at least in those individuals with more potent cold hemagglutinins.

Lake (16) studied the effect of low temperature on tissue cultures and concluded that the survival time of tissues was shorter at a temperature in which anabolic processes were reduced to a greater degree than catabolic processes. He found temperatures of approximately 15° C. most injurious. Lake assumed that at higher temperatures the anabolic and catabolic processes were more nearly parallel while at lower temperatures both processes were brought to a standstill. It is conceivable, therefore, that rewarming frostbitten tissues sufficiently to create a disparity between anabolic and catabolic processes but not enough to reverse cold hemagglutination and re-establish circulation may subject the part to greater damage than if the tissues were rewarmed rapidly to normal temperature.

Cold hemagglutination may play a part in the pathophysiology of human frostbite because it seems inevitable that intravascular cold hemagglutination occurs in most cases if the tissues become cold enough for a long enough period of time. Further studies are necessary to elucidate the relationship of temperature and exposure time to cold hemagglutination. In the present investigation emphasis was placed on the importance of cold agglutination during the cold exposure period rather than the rewarming phase of frostbite. Because of the apparent difference between cooling and rewarming thresholds of cold hemagglutination it may be that more attention should be given to the

relationship of rapidity of rewarming with cold hemagglutination titer and severity of injury. Accurate measurement of rapidity of rewarming of cases in this series was an impossibility.

The analysis suggested the possibility that individuals with low titers or absence of cold hemagglutinins may have had resistance to frostbite, but there was no demonstrable relationship between titers found in frostbite patients and degree of exposure necessary to produce lesions or to the severity of injury incurred.

V. CONCLUSIONS

1. This study indicated a high incidence of cold hemagglutinins in normal soldiers. The main factor contributing to this high incidence was believed to be careful control of refrigeration and reading temperature during conduct of the tests.
2. There was a racial difference in cold hemagglutinating tendencies. The United States Negroes had significantly higher titers than Whites. The Mongolians had much higher titers than either Whites or Negroes.
3. Repeated exposures of post-frostbite patients to cold had no appreciable effect on their existing cold hemagglutinin titers.
4. No relationship was demonstrated between the cold hemagglutinin titers and the anatomical site of frostbite. There was no evidence of alteration of cold hemagglutination by frostbite.
5. There was no relationship between cold hemagglutinin titer values of frostbite patients and minimum temperature during

exposure, average windchill during exposure or duration of exposure. Likewise, the differences between titer values for patients with a maximum injury of third degree and minimum temperature during exposure or duration of exposure were not significant. The analyses of the data indicated that cold hemagglutination was probably not of overwhelming importance in the pathogenesis of frostbite.

6. Analysis indicated that climatic environment might have a significant modifying effect on cold hemagglutinin titers. A theory was proposed that when an individual is exposed to cold weather for weeks or months a reduction in titer might occur as a result of an increased rate of destruction of cold agglutinin. Data relative to native climatic regions indicated a lack of permanent alteration of cold agglutinins by environment.

7. It was postulated that only the few individuals having titers of 1:4 or less might have a resistance to frostbite as suggested by a trend of low incidence of such low titers among cold injured subjects.

8. Studies indicated that potent "normal" cold hemagglutinins had narrow thermal amplitudes. The rewarming thermal amplitudes were, however, higher than the cooling amplitudes. This disparity in cold hemagglutination was discussed with respect to the rewarming phase of frostbite, i.e. the advisability of rapid rewarming.

9. In this study the degree of cold hemagglutination had no practical value in classification or prognosis of frostbite.

It is doubtful if cold hemagglutinin tests could be used as a screening procedure for detecting individuals who might be susceptible to injury by cold.

VI. BIBLIOGRAPHY

1. Weiner, D. The role of cold hemagglutinins in frostbite. Report No. 67, AMRL Project No. 6-62-12-3, 1951.

2. Parker, F. F. Personal communication, 1943, cited by W. R. Platt and C. S. Ward, Jr. (27).

3. Stats, D. and L. R. Wasserman. Cold hemagglutination - an interpretive review. Medicine, 22: 363, 1943.

4. Lange, K., D. Weiner and L. J. Boyd. Frostbite, physiology, pathology and therapy. New England J. Med. 237: 373, 1947.

5. Iwai, S. and M. Mei-Sai. Etiology of Raynaud's syndrome. Jap. Med. World 5: 119, 1925.

6. Jessen, C. V. and J. Bing. Methods for differentiating cause of increased sedimentation rate II. Demonstration of hyper-autoagglutinaemia (pathological cold agglutination) by microscopy, agglutinin titration of thermoamplitude, and simultaneous determination of the sedimentation rate at room temperature and at 37°. Acta Med. Scandinav. 105: 287, 1940.

7. Stats, D. and J. G. M. Bullowa. Cold hemagglutination with symmetric gangrene of the tips of the extremities. Arch. Int. Med. 72: 506, 1943.

8. Robinette, R. C. and C. P. Foreman, Jr. Errors in blood grouping. M. Tech. Bull. 3: 237, 1952.

9. Gradwohl, R. B. H. Clinical laboratory methods and diagnosis. Ed. 4, St. Louis, C. V. Mosbey Co., 1: 869, 1948.

10. Siple, P. S. and C. F. Passel. Measurements of dry atmospheric cooling in sub-freezing temperatures. Proc. Am. Phil. Soc. 89: 176, 1945.

11. Orr, K. D. and D. Fainer. Cold injuries in Korea during winter of 1950-51. Medicine 31: 177, 1852.

12. Culler, E. Studies in psychometric theory. J. Exper. Psychol. 9: 271, 1926.

13. Fetterman, G. H., T. J. Moran and W. R. Hess. The cold hemagglutination test. I) Studies on Naval hospital patients II) Studies on natives in yaws-endemic area. U. S. Nav. Bull. 43: 1128, 1944.

14. Kreyberg, L. Development of acute tissue damage due to cold. Physiol. Rev. 29: 156, 1949.

15. Clough, M. C. and I. M. Richter. A study of autoagglutinin occurring in human serum. Bull. Johns Hopkins Hosp. 29: 86, 1918.

16. Lake, N. C. An investigation into the effects of cold upon the body. Lancet. 2: 557, 1917.

ARMY MEDICAL RESEARCH LABORATORY

FORT KNOX, KENTUCKY

REPORT NO. 113
1 April 1953

COLD INJURY - KOREA 1951-52*

Section XIV
THE SIGNIFICANCE OF SICKLING TRAIT IN NEGRO FROSTBITE CASUALTIES

*Subtask under Environmental Physiology, AMRL Project No. 6-64-12-028, Subtask (CK), Cold Injury Studies.

MEDICAL RESEARCH AND DEVELOPMENT BOARD
OFFICE OF THE SURGEON GENERAL
DEPARTMENT OF THE ARMY

TABLE OF CONTENTS

THE SIGNIFICANCE OF SICKLING TRAIT
IN NEGRO FROSTBITE CASUALTIES

I. INTRODUCTION

Sickling, an inherited abnormality of erythrocytes peculiar to individuals of Negro ancestry has an estimated incidence of 9.0% among Negroes in the United States (1). Sickle cell anemia is a well recognized disease entity dependent on a severe degree of erythrocyte sickling. Sickle cell trait, a characteristic in which the individual's erythrocytes have by contrast a much weaker sickling tendency, is of debatable clinical importance (1,2). It is probable, however, that the trait is usually compatible with good health and long life (1,2).

The earlier concepts of the relationship between sickle cell anemia and sickle cell trait assumed a merging of the two conditions. Such gradations of severity would make difficult a differentiation between entities manifested by an intermediate sickling tendency (2). Subsequent investigations (Table 1) concerning the nature of inheritance (3,4,5,6), the hemoglobin abnormality characterizing the sickle cell (7,8,9) and the threshold for sickling as dependent on the extent of hemoglobin reduction (10,11,12) have indicated there is ordinarily a sharp difference between the degree of erythrocyte abnormality in sickle cell anemia and sickle cell trait. This corresponds with the usual clinical experience that the two conditions are readily differentiated. Evidence that there might be occasional Negroes with intermediate sickling tendency has been presented, however, by Wells and Itano (9) who found electrophoretic patterns

indicating hemoglobin abnormality of intermediate degree in certain individuals with relatively mild sickle cell anemia.

TABLE 1

REVIEW OF DIFFERENCES BETWEEN SICKLE CELL ERYTHROCYTE IN SICKLE CELL ANEMIA AND IN SICKLE CELL TRAIT

Factor	Abnormality		Sickle Cell Anemia	Sickle Cell Trait	Bibliography
Inheritance	Gene for Sickling		Homozygous	Heterozygous	(3), (5), (6)
Hemoglobin	"Sickle Cell Hemoglobin" Content of Erythrocytes		Over 90%	24 - 45%	(7), (8), (9)
Sickling Threshold	In Vitro	Lowered Oxygen Tension Necessary for Sickling	Above 45mm. Hg.	Below 18mm. Hg.	(10), (11)
	In Vivo	Proportion of Erythrocytes Sickled in Venous Blood	30 - 60%	0 - 1%	(11)

The estimates of the proportion of Negroes with positive sickling reaction having sickle cell anemia vary widely (1). The ratios of 1:40 suggested by Diggs, Ahmann and Bibb (13) and 1:50 found by Sydenstricker (14) agree with that of 1:44 predicted by Neel (5,6) on the basis of his theory of inheritance of the sickle cell.

Despite the paucity of evidence favoring a pathologic significance of sickle cell trait, the studies to be reported here were

based on the assumption that intravascular sickling might have some bearing on development of frostbite in Negroes, particularly in view of a suspected greater frostbite susceptibility of Negroes as compared to Whites (15). The investigation was directed toward demonstrable influence of sickle cell trait on the pathogenesis of frostbite, the severity of lesions incurred and on the healing of third degree ulcers.

An incidental analysis was concerned with the relationship between cold hemagglutination and sickling trait.

II. METHODS

Of 264 Negro patients treated for frostbite at Osaka Army Hospital during the winter 1951-52, 179 were evaluated with respect to sickling. Sickling preparations were made by one of the following methods:

1) One drop of venous blood was sealed between a glass slide and a coverslip ringed with petrolatum or paraffin (Emmel 17).

2) A rubber band was placed and allowed to remain around the proximal portion of the finger for 5 minutes in order to produce venous stasis. The distal end of the finger was then punctured and a drop of blood was sealed under a coverslip as in the previous method (Scriver and Waugh 18).

The preparations (which were not sterile) were kept between 25° to 37° C. and examined for characteristic sickle cells at intervals during the ensuing 72 hours using low and high power magnifications.

The patients' clinical records provided information as to the past clinical history, severity of injury and healing time of third degree frostbite lesions. The laboratory records included blood counts and cold hemagglutination tests. The cold hemagglutination tests were done by a modified method described in Section XIII of this combined report.

III. RESULTS

Eighteen of the 179 Negroes tested had positive sickling tests, an incidence of 10.1%. The blood counts of all eighteen individuals with positive tests were normal and none had a past clinical history or symptoms suggestive of sickle cell anemia. Consequently, they were regarded as having sickle cell trait.

The incidence of 10.1% was compared (Table 2) with the incidence of sickling in Negroes of the United States reported by Margolies (1), who combined results of 28 reported series, comprising 22,170 Negroes tested in various parts of the country, to arrive at the figure 9.0%. A comparison (Table 2) was also made with results reported by Ellenhorn and Weiner (16) from 66 frostbitten soldiers and 346 uninjured troops studied during winter maneuvers at Camp Drum, New York between 6 January and 23 February 1952. The statistical analyses showed that incidence of erythrocyte sickling in the present study did not differ significantly from either control or frostbite groups reported by the above authors.

The distribution of positive and negative sickling tests of patients with each of the four degrees of injury is shown in Table 3. The chi square test of these distributions (0.596, P >.1) indicated

an even incidence of sickle cell trait among patients with different degrees of injury.

TABLE 2

COMPARISON BETWEEN SICKLING INCIDENCE AMONG 179 NEGRO FROSTBITE PATIENTS AND SICKLING INCIDENCES AMONG NEGROES IN OTHER REPRESENTATIVE SERIES

Series	Bibliography	Tested	Positive	%	Comparison with 1951-52 Korea Frostbite Series	
					Chi Square	P
Negro Frostbite Patients Korea, 1951-52	Wimer (Present Report)	179	18	10.1		
Negro Population of United States	(1)*	22,170	1989	9.0	0.225	>.5
Negro Frostbite Patients Camp Drum, 1952	(16)	66	9	13.6	0.630	>.3
Uninjured Negroes Camp Drum 1951-52	(16)	346	36	10.4	0.015	>.9

* Combined Results of 28 Reported Series by Different Authors.

TABLE 3

ANALYSIS OF SICKLING INCIDENCE AMONG 179 NEGRO FROSTBITE PATIENTS ACCORDING TO DEGREES OF MAXIMUM INJURY

Sickling Test	Total Cases	Degree Maximum Injury				Chi Square	P
		1°	2°	3°	4°		
Positive	18	1	8	7	2	0.59%	>.70
	10.0%	8.3%	10.7%	8.9%	15.4%		
Negative	179	11	67	72	11		

In a comparison between the healing times of third degree lesions of Negroes with sickle cell trait and those with negative sickling tests, data were available for 51 Negro patients negative for sickling but for only five patients with sickle cell trait. The average time of healing was greater in the positive group (75 days, S.D. $\pm$34.2 days) then in the negative group (53 days, S.D. $\pm$17.3 days) but the difference was not statistically significant in this limited sampl. ($t = 1.407$, $P > .1$).

A comparison also was made of the cold hemagglutinin titers of eight patients with sickle cell trait and 99 patients with negative sickling tests (Table 4). The coded cold hemagglutinin titer values of the group with sickle cell trait (5.1 $\pm$1.85) were somewhat higher than the negative group (4.7 $\pm$1.30) but again the difference was not statistically significant in this limited study group ($t = 0.658$, $P > .50$).

TABLE 4

COMPARISON BETWEEN COLD HEMAGGLUTININ TITERS OF 8 SICKLING POSITIVE AND 99 SICKLING NEGATIVE FROSTBITE PATIENTS

Sickling Test	Cold Hemagglutinin Titer and Coded Value									
	Neg. (0)	1:2 (1)	1:4 (2)	1:8 (3)	1:16 (4)	1:32 (5)	1:64 (6)	1:128 (7)	1:256 (8)	1:512 (9)
Positive	0	0	0	2	1	2	0	3	0	0
Negative	0	0	4	13	28	28	20	4	1	1

IV. DISCUSSION

Interest in the pathogenetic possibilities of the sickle cell trait was directed to three phases of frostbite injury: the period preceding onset of injury; the period following rewarming during which definitive lesions were established and the period of healing.

Any deleterious effect of sickling trait would be hypothetically based on local vascular stasis and occlusion analogous to that responsible for many of the protean manifestations of sickle cell anemia. The weakness of sickling tendency in sickle cell trait, however, is the limiting factor of the trait being an important clinical entity, even under extreme circumstances which predispose to intravascular sickling.

Sherman (11) verified the findings of Hahn and Gillespie (10) that sickling of susceptible cells in a sealed preparation is accelerated not only by an increased concentration of leukocytes or by bacterial contamination but also by temperature elevation. These studies showed, furthermore, that at temperatures 25° C. or lower, sickling does not occur in sterile preparations from individuals with sickle cell trait. This inhibiting action of lowering temperature may outweigh any anoxemic effect from vasoconstrictive response in an exposed limb during the development of frostbite. In view of these facts alone, the normal incidence of sickling trait among frostbite patients, a result which failed to indicate an importance of the trait, was not surprising. It appears that the role of sickle cell trait in the pathogenesis of frostbite was not an important one.

If intravascular sickling were a factor during the phase of injury immediately following rewarming, sickling positive Negroes

should have been predisposed to development of the more severe injuries. The absence of bias in favor of more severe lesions among the 18 patients with sickle cell trait implied a lack of importance of sickling in frostbite lesions during the post-rewarming phase of injury.

The selection of third degree injuries for an analysis regarding healing time was based mainly on the occurrence of ulcers and the rather definite criteria for determining healing time (a complete re-epithelization of ulcers). The healing phase of third degree lesions extends well beyond the period of the "warm dry limb" into the period of vasomotor instability associated in most cases with a "cold hyperhidrotic limb", a change which usually starts approximately 4 weeks after injury. Thus, circulatory disturbance in individuals with sickle cell trait might conceivably be accompanied by sufficient anoxemia to predispose the involved tissues to intravascular sickling and more severe circulatory stasis. Such a chain of events might be reflected in demonstrable impairment of healing. By analyses the average healing time of third degree lesions was slower for five Negroes with sickle cell trait than for 51 patients with negative sickling tests, but the difference was not statistically significant. Conclusions must be reserved in this study because of the inadequacy of sampling of the group with sickle cell trait.

McSweeney, Mermann and Wagley (17) made comparative studies of the incidence of cold hemagglutinins in 30 patients with sickle cell anemia and 30 healthy Negro subjects. The titers may have been higher

in the former group, but the results were difficult to assess because of the lack of detailed information. Schneider and Levin (18) searched for auto-agglutinin in studies of sickling positive individuals using saline and bovine albumin diluents and Coombs antiserum. These tests were done at 38° C. Reactions were consistently strongly positive in the group with sickle cell anemia and only weakly positive in some of the individuals with sickle cell trait. The results implied the presence in patients with sickle cell anemia of auto-agglutinin (active at 38° C.) which was present also, but to a much weaker extent, in some individuals with sickle cell trait.

The present investigation regarding the relative cold hemagglutinating tendencies of eight frostbite patients with sickle cell trait and 99 Negro patients negative for sickling must be regarded as inconclusive because of the inadequate sample in the former group.

V. CONCLUSIONS

1. The incidence of 18 positive sickling tests among 179 Negro frostbite patients (10%) did not differ significantly from the expected incidence in an average United States Negro population.
2. On the basis of histories, clinical evaluations and blood counts, the 18 individuals with positive tests were all diagnosed as having sickle cell trait in contradistinction to sickle cell anemia.
3. There was no demonstrable relationship between sickling trait and severity of cold injury.
4. The average healing time of third degree lesions was longer

for five patients with positive sickling than for 51 Negro patients with negative sickling tests although the difference was not statistically significant. The possibility of intravascular sickling causing retardation of ulcer healing could not be established, because of the limited sample of sickle cell positive individuals with third degree injury.

5. The cold hemagglutinin titers of eight patients with sickle cell trait were not significantly higher than those of 99 individuals negative for sickling.

VI. BIBLIOGRAPHY

1. Margolies, M. P. Sickle cell anemia, A composite study and survey. Medicine 30: 357, 1951.

2. Wintrobe, M. M. Clinical hematology, Ed. 2, Philadelphia, Lea and Febriger, 515, 1946.

3. Huck, J. G. Sickle-cell anemia. Bull. Johns Hopkins Hosp. 34: 335, 1923.

4. Taliaferro, W. H. and J. G. Huck. The inheritance of sickle-cell anemia in man. Genetics 8: 594, 1923.

5. Neel, J. V. The inheritance of sickle cell anemia. Science 110: 64, 1949.

6. Neel, J. V. The inheritance of the sickling phenomenon, with particular reference to sickle cell disease. Blood 6: 389, 1951.

7. Pauling, L., H. A. Itano, S. J. Singer and I. C. Wells. Sickle cell anemia: A molecular disease. Science 110: 543, 1949.

8. Pauling, L., H. A. Itano, I. C. Wells, W. A. Schroeder, L. M. Kay, S. J. Singer and R. B. Corey. Sickle cell anemia hemoglobin. Science 111: 459, 1950.

9. Wells, I. C. and H. A. Itano. Ratio of sickle-cell anemia hemoglobin to normal hemoglobin in sicklemics. J. Biol. Chem. 188: 65, 1951.

10. Hahn, E. V. and E. B. Gillespie. Sickle cell anemia; report of case greatly improved by splenectomy; experimental study of sickle cell formation. Arch. Int. Med. 39: 233, 1927.

11. Sherman, I. J. The sickling phenomenon, with special reference to the differentiation of sickle cell anemia from the sickle cell trait. Bull. Johns Hopkins Hosp. 67: 309, 1940.

12. Lange, R. D., V. Minnich and C. V. Moore. In vitro differences in behavior of sickle cell anemia and trait erythrocytes produced by variation in O_2 tension and pH. J. Lab. and Clin. Med. 36: 848, 1950.

13. Diggs, L. W., C. F. Ahmann and J. Bibb. Incidence and significance of the sickle cell trait. Ann. Int. Med. 7: 769, 1933.

14. Sydenstricker, V. P. In discussion of Diggs, L. W. The blood picture in sickle cell anemia. South. M. J. 25: 615, 1932.

15. Orr, K. D. and D. C. Fainer. Cold injuries in Korea during winter of 1950-51. Medicine 31: 177, 1952.

16. Ellenhorn, M. J. and D. Weiner. Sickle cell trait and frostbite. Report No. 81, AMRL Project No. 6-64-12-028, 14 Apr. 1952.

17. McSweeney, J. E., A. C. Hermann and P. F. Wagley. Cold hemagglutinins in sickle cell anemia. Am. J. M. Sc. 214: 542, 1947.

18. Schneider, R. G. and W. C. Levin. Production of specific antisera against sickle cell anemia erythrocytes; antibody in sicklemia sera. Proc. Soc. Exper. Biol. and Med. 75: 110, 1950

ARMY MEDICAL RESEARCH LABORATORY

FORT KNOX, KENTUCKY

REPORT NO. 113
1 April 1953

COLD INJURY - KOREA 1951-52*

Section XV
PROTEIN STUDIES ON FROSTBITE PATIENTS

*Subtask under Environmental Physiology, AMRL Project No. 6-64-12-028, Subtask (SK), Cold Injury Studies.

MEDICAL RESEARCH AND DEVELOPMENT BOARD
OFFICE OF THE SURGEON GENERAL
DEPARTMENT OF THE ARMY

SECTION XV

PROTEIN STUDIES

ON FROSTBITE PATIENTS

by

Walter R. Koehler
Cpl. USA

and

Leonard J. Bodenlos
Lt. MSC, USN

TABLES OF CONTENTS

PROTEIN STUDIES ON FROSTBITE PATIENTS

I. INTRODUCTION

A survey of the protein levels of fasting blood sera and vesicular fluids of frostbite patients at Osaka Army Hospital was made during the winter of 1951-52.

It was of interest to study the serum protein levels of these patients, because there is evidence to show that depletion of body protein leads to prolonged convalescence, poor wound healing and an increase in complications after surgery. Pollock and Halpern (1) summarizing the literature for the Committee on Therapeutic Nutrition of the National Research Council stated that: "protein metabolism may be increased after injury. The soldier who has been wounded severely enough to require more than 10 days hospitalization will require larger amounts of protein than is supplied by routine diets. The urinary nitrogen losses from the injury response may be very high and the negative nitrogen balance, even in the absence of excessively high excretion, can be accentuated by bed rest". Their report, as well as studies by Sinclair (2) and Youmans, et al (3) indicated that serum protein concentration is not a very satisfactory index of protein status in general. This is believed true because the serum protein concentration does not always accurately denote either the protein concentration in the tissues or in the circulation. The body zealously attempts to maintain the concentration of serum protein at nearly normal level at the expense of tissue proteins. Data concerning the protein concentration in the blood of frostbite casualties were not

found in the literature.

II. METHOD

The protein survey followed was that of Wolfson and coworkers (4) as described by Consolazio et al (5). The following procedure was used in this study. The total protein, albumin, total globulin and the alpha globulin, beta globulin and gamma globulin fractions were separated by precipitation and measured colorimetrically in a Coleman spectrophotometer by the addition of an alkaline copper sulfate reagent (biuret) which produced a bluish-purple color. A 28% sodium sulfite solution was used to precipitate the total globulin, 23% sodium sulfate to precipitate the beta and gamma globulin and 19.3% ammonium sulfate in 4% saline to precipitate the gamma globulin fraction. A 1% Span-ether solution was used to aid in separating the total globulin precipitate from the centrifugate. Of these six values the total protein, albumin and gamma globulin were measured directly. The other three values were calculated by difference.

Ninety-nine samples of serum were analyzed in duplicate. The mean of the differences between the duplicate values was 2.4% in the case of total protein and approximately 3% for albumin and gamma globulin. The variations in the alpha globulin and beta globulin fractions, and frequently in the total globulin, were higher because these fractions were measured as the differences of the other larger components. The values were converted to grams per 100 cc. of serum by means of a standard curve made with a sample of commercial Human Serum Albumin, 25 grams per 100 cc. which is normally used for therapy

at army hospitals.* Points on the prepared curve were verified in this study by the Micro-Kjeldahl method.

Three hundred and eight patients were studied as follows:

1) The fasting sera of 262 frostbite patients were examined within the first 48 hours after admission. Among these were 51 study patients from whose sera additional determinations were made for a period of more than one month. From three to seven determinations were made for each study patient.

2) In addition, 46 other study patients who had been hospitalized for periods ranging from 1 to 8 weeks were also studied serially, although no tests were performed at time of admission.

3) The total protein content of the vesicular fluids of 26 patients was determined concomitantly with the fasting serum proteins. These samples were generally obtained within 48 hours after admission.

III. RESULTS

The mean protein values for 262 patients on their first day of hospitalization are given in Table 1 and Figures 1 through 7.

In spite of the fact that these data were obtained from soldiers with frostbite, the values were essentially normal according to the ranges reported for this method by Wolfson, et al (4) and compared favorably with protein data in the literature for normal civilian and military (6) male adults obtained by both Micro-Kjeldahl and elec-

*This product, Lot No. 63, was manufactured by the Armour Laboratories, Fort Worth, Texas, for the army from pooled human blood. The amount of total protein varies no more than ±1.0 gram in 25 grams per 100 cc., according to the requirements of the National Institute of Health (verified by Kjeldahl method).

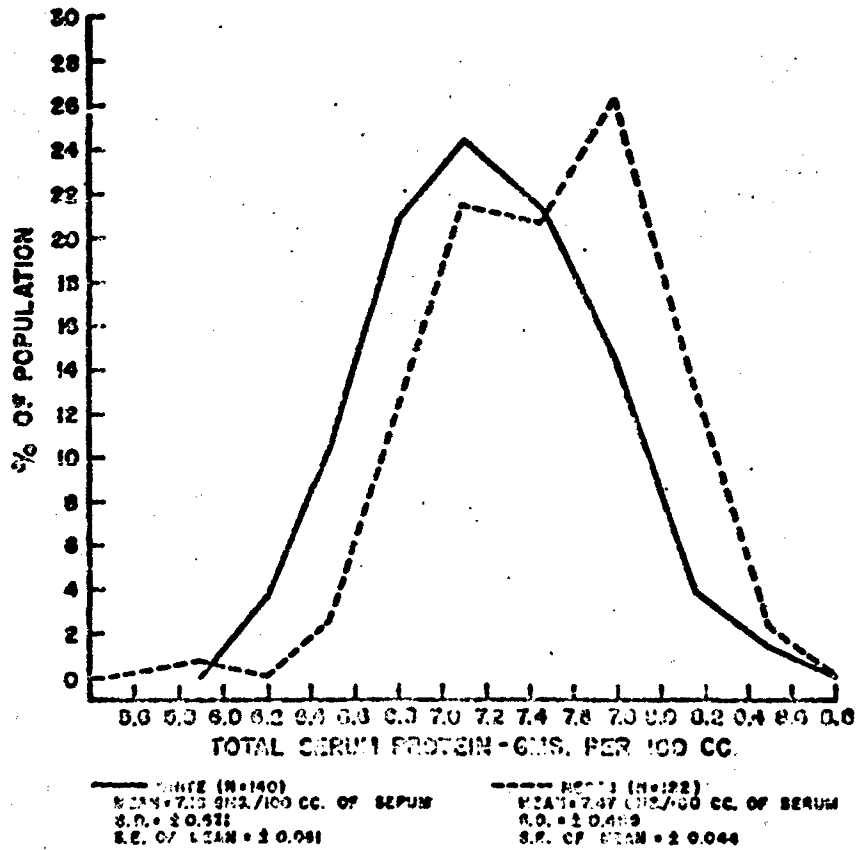


FIGURE I. DISTRIBUTION OF TOTAL PROTEIN VALUES OF FROSTBITE PATIENTS UPON ADMISSION TO OSAKA ARMY HOSPITAL.

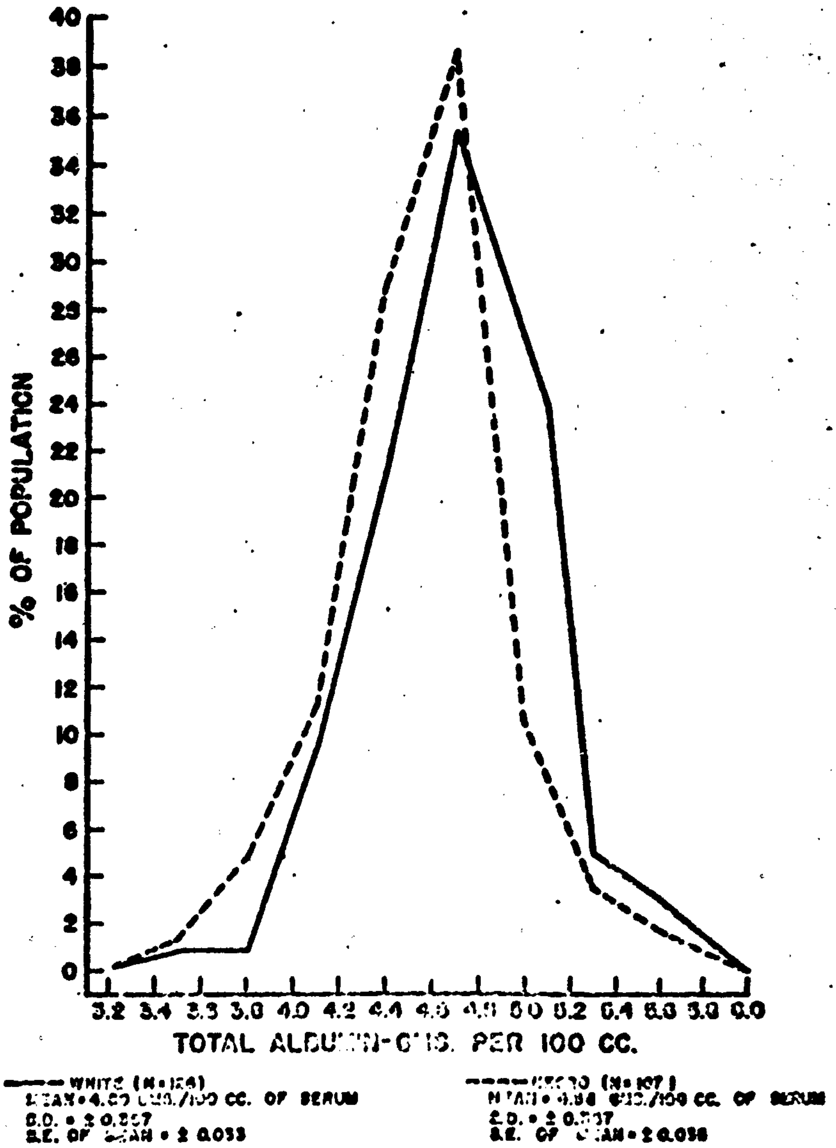


FIGURE 2. DISTRIBUTION OF TOTAL ALBUMIN VALUES OF FROST-BITE PATIENTS UPON ADMISSION TO OSAKA ARMY HOSPITAL.

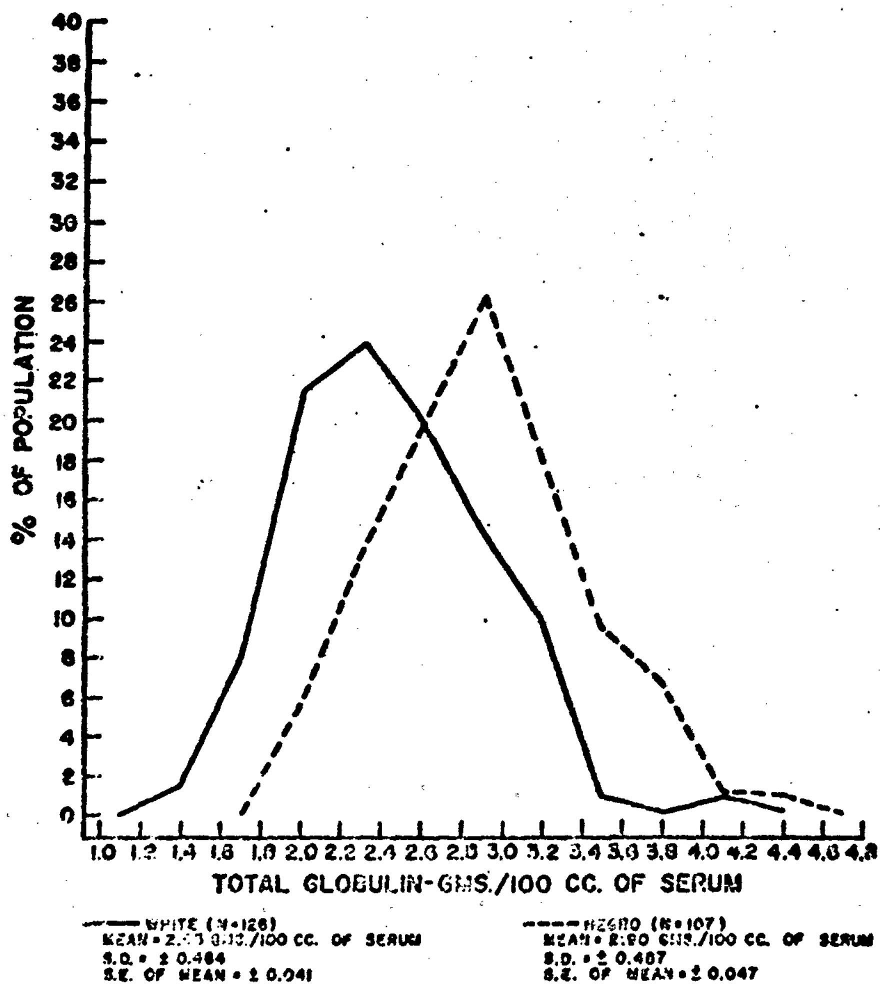


FIGURE 3. DISTRIBUTION OF TOTAL GLOBULIN VALUES OF FROSTBITE PATIENTS UPON ADMISSION TO OSAKA ARMY HOSPITAL.

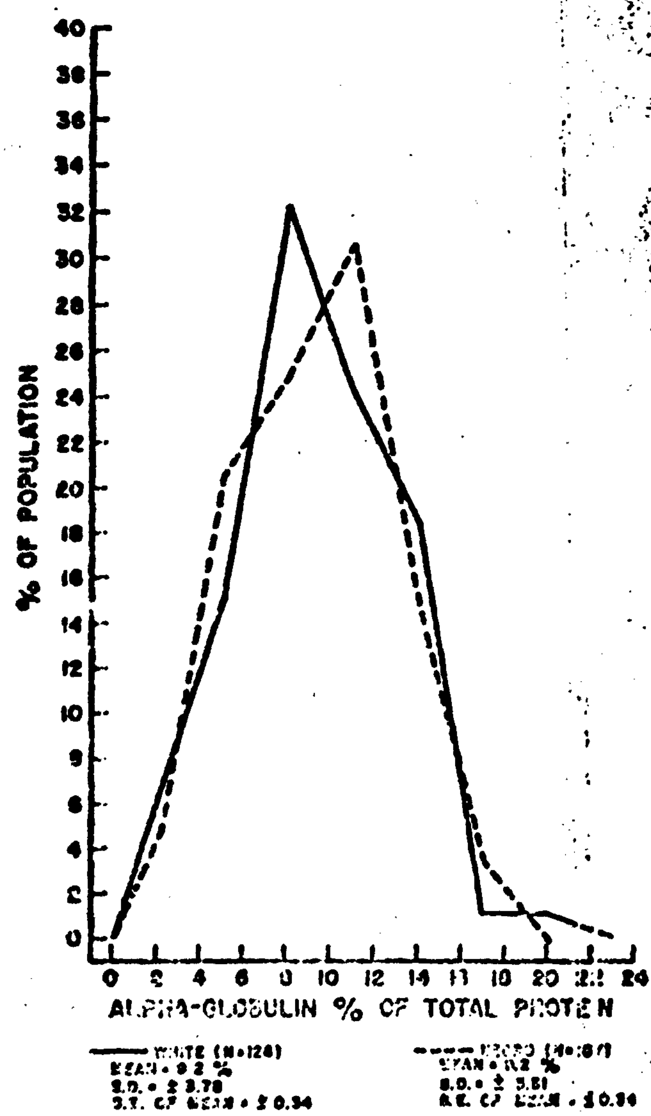


FIGURE 4. DISTRIBUTION OF ALPHA-GLOBULIN VALUES OF FROSTBITE PATIENTS UPON ADMISSION TO OSAKA ARMY HOSPITAL.

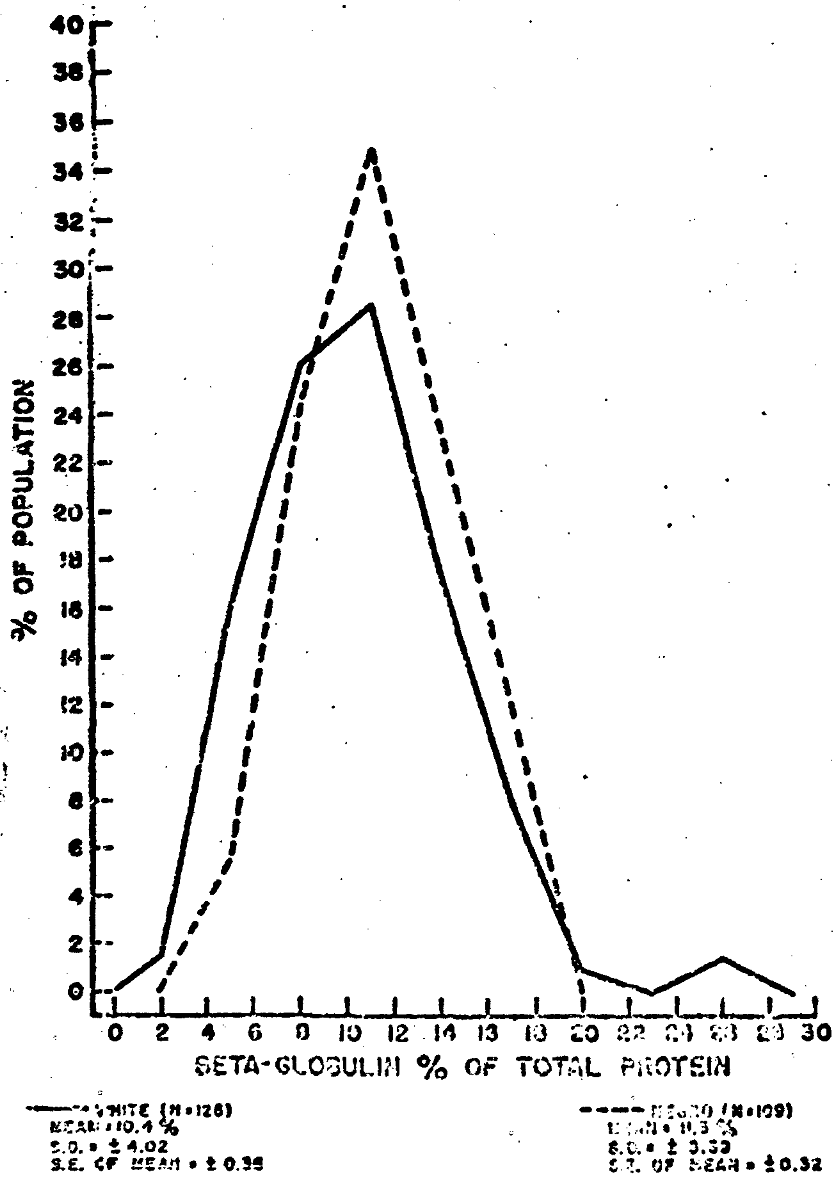


FIGURE 5. DISTRIBUTION OF BETA-GLOBULIN VALUES OF FROST-BITE PATIENTS UPON ADMISSION TO OSAKA ARMY HOSPITAL.

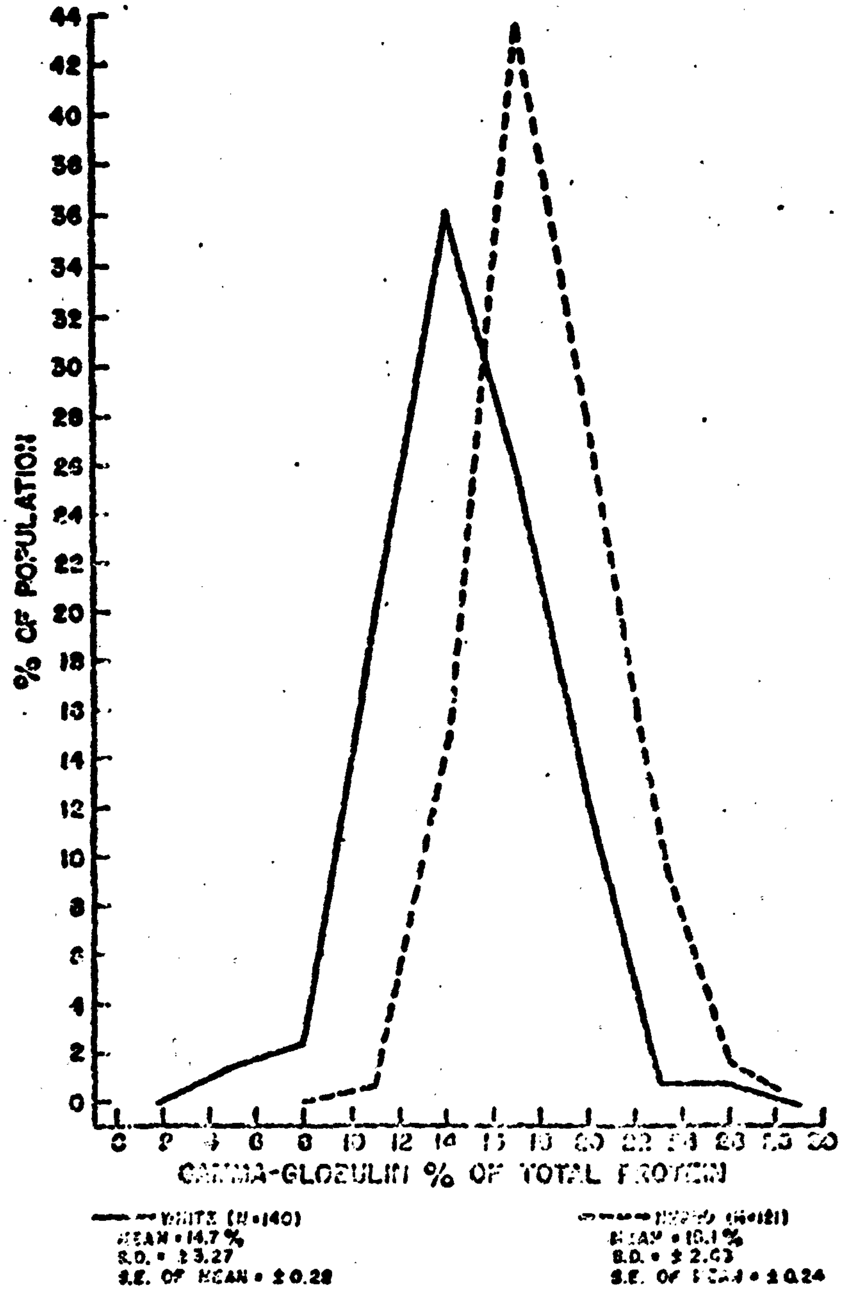


FIGURE 6. DISTRIBUTION OF GAMMA-GLOBULIN VALUES OF FROST-BITE PATIENTS UPON ADMISSION TO OSAKA ARMY HOSPITAL.

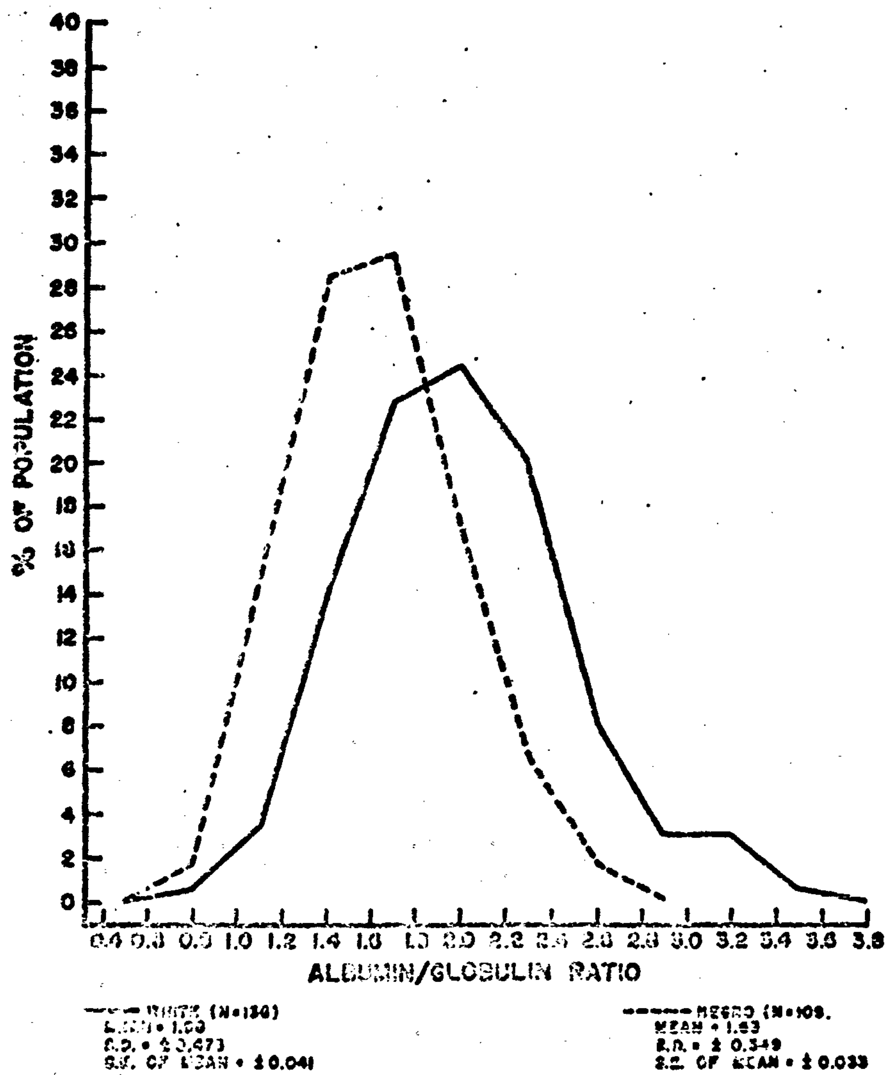


FIGURE 7. DISTRIBUTION OF A/G RATIOS OF FROSTBITE PATIENTS UPON ADMISSION TO OSAKA ARMY HOSPITAL.

TABLE 1

PROTEIN LEVELS OF FASTING SERA OF 262 FROSTBITE CASUALTIES

Fraction	Mean	Standard Deviation
Total Protein	7.30 gms/100 cc.	±0.509
Albumin	4.63 gms/100 cc.	±0.373
Total Globulin	2.66 gms/100 cc.	±0.527
Alpha Globulin	9.21 %*	±3.664
Beta Globulin	10.83 %*	±3.776
Gamma Globulin	16.31 %*	±3.461
A/G Ratio	1.82	±0.459

*% of Total Protein

trophoretic methods (Table 2).

In comparing the White and Negro patients, statistically significant differences between the respective means of total protein, albumin, total globulin, gamma globulin and the A/G ratios were found. The significances of these differences as calculated by the Fisher "t" test are presented in Table 3.

It is to be noted that an average of 9.6 days had elapsed from the time the casualties left the front lines until they were admitted to the hospital in Osaka, Japan. The time post-injury that 43 White and 52 Negro patients were admitted to Osaka Army Hospital averaged 10.9 and 8.5 days respectively. No data were available relative to the blood protein levels of casualties immediately after incurring a cold injury. It was therefore of interest to follow the blood protein levels of the patients during their hospitalization. Serial determinations of the six protein fractions were made on the sera of 97 study patients. The mean protein values of the analyses

TABLE 2

NORMAL VALUES OF SERUM PROTEIN
OF CIVILIAN SUBJECTS

Bibliography	Method	Locality	Total Serum Protein gms/100 cc.	Serum Albumin gms/100 cc.	Total Serum Globulin gms/100 cc.	A/G Ratio	Alpha Globulin % of Total Protein	Beta Globulin % of Total Protein	Gamma Globulin % of Total Protein
Wolfson 1948 (4)	Colorimetric* (Biuret) Pooled Sera	Ill.	7.01	3.77	3.24	1.16	15.7%	13.4%	17.1%
Anderson 1951 (7)	Literature Values	Unknown	6.5 - 8.0	4.0 - 5.7	-	1.72	6 - 15	11 - 17	9 - 16
Lewis 1950 (8)	Electrophoretic Plasma	Ohio	5.9 - 7.8	3.7 - 5.1	-	1.39	6 - 9	11 - 16	8 - 15
Peters Eiseman 1933 (9)	Kjeldahl	Conn.	6 - 8	4.0 - 5.5	1.4 - 3.0	-	-	-	-
Luetscher 1941 (10)	Electrophoretic Plasma	Mass.	6.0 - 6.9	4.1	2.4	-	7.0	13.2	11.6

*Checked with electrophoretic measurements

TABLE 3

RACIAL COMPARISON OF INITIAL MEAN PROTEIN LEVELS OF 262 CASES OF FROSTBITE

Fraction	Race	No. of Patients	Mean	Standard Deviation	t	P
Total Protein	White	140	7.16	± 0.631	4.477	<.01
	Negro	122	7.47	± 0.489		
Albumin	White	126	4.69	± 0.367	2.698	<.01
	Negro	107	4.56	± 0.367		
Total Globulin	White	126	2.45	± 0.464	7.181	<.01
	Negro	107	2.90	± 0.487		
Alpha Globulin	White	126	9.23	± 3.786	0	
	Negro	107	9.23	± 3.514		
Beta Globulin	White	126	10.41	± 4.021	1.864	>.05
	Negro	109	11.35	± 3.398		
Gamma Globulin	White	140	14.78	± 3.273	9.243	<.01
	Negro	121	18.12	± 2.681		
A/G Ratio	White	136	1.93	± 0.475	6.731	<.01
	Negro	107	1.63	± 0.349		

made on the fourteenth and thirtieth day of hospitalization are given in Table 4.

The protein levels of the vesicular fluids of 26 patients ranged from 2.0 to 14.9 grams per 100 cc. The mean total protein of the vesicular fluid was 6.71 grams per 100 cc. ±2.49. The vesicle fluid was obtained under aseptic technique from intact blisters 3 to 15 days after injury. No significant coefficient of correlation was found between the total protein of the sera and the vesicle fluids for these 26 patients (Table 5).

Significant differences were found between the means of certain protein fractions of the sera for the different degrees of frostbite incurred (Tables 6-11). Although the means calculated for each degree of frostbite were all within the normal range a slight rise was noted in all of the globulin fractions with increased severity

TABLE 4

MEAN PROTEIN LEVELS FOR 68 FROSTBITE PATIENTS DISTRIBUTED ACCORDING TO RACE AND DAY OF HOSPITALIZATION

Total Protein and Fractions	Race	Day of Hospitalization in Osaka					
		1 Day		14 Days		30 Days	
		No. Tested	Mean	No. Tested	Mean	No. Tested	Mean
Total Protein gms/100 cc.	White	21	7.23	31	7.24	20	7.41
	Negro	30	7.41	37	7.50	22	7.54
Albumin gms/100 cc.	White	21	4.76	31	4.81	20	4.92
	Negro	30	4.54	37	4.53	22	4.63
Total Globulin gms/100 cc.	White	21	2.55	31	2.56	20	2.57
	Negro	30	2.97	37	2.92	22	2.96
Alpha Globulin % of Total Protein	White	21	10.0	31	10.0	20	9.0
	Negro	30	10.0	37	10.0	22	10.0
Beta Globulin % of Total Protein	White	21	11.0	31	10.0	20	9.0
	Negro	30	12.0	37	12.0	22	12.0
Gamma Globulin % of Total Protein	White	21	15.0	31	15.0	20	15.0
	Negro	30	18.0	37	18.0	22	17.0

of frostbite, while the albumin level dropped and the total protein remained relatively constant. Statistically, the means of the albumin, alpha globulin, beta globulin and gamma globulin of the patients with first, second and third degree frostbite were not significantly different. However the means of the albumin, alpha globulin and gamma globulin fractions of patients with fourth degree frostbite differed significantly from the corresponding values of patients with a less severe degree of frostbite (Table 12). A significant difference was noted between the total protein of patients with third degree frostbite as compared with first degree cases ($t=2.645$, $P <.01$).

Blood counts were made on all admissions. No remarkable abnormalities were noted. The distribution of hematocrit values was normal (Figure 8). Four hundred seventy-eight patients were examined and a mean of 47.2 was found. The range was from 35 to 55 with 90% of the values falling between 43 and 51. Sunderman (11) gives the

TABLE 5

DISTRIBUTION OF TOTAL PROTEIN VALUES IN SERA OF 26 PATIENTS IN ACCORDANCE WITH THE TOTAL PROTEIN LEVELS IN THEIR VESICULAR FLUIDS

Case Number	Total Serum Protein Level at Time of Admission to Osaka Army Hospital gms/100 cc.	Total Protein in Vesicular Fluid gms/100 cc.
50	6.7	7.4
51	6.1	14.9
52	6.8	5.7
54	6.7	2.0
55	7.3	5.3
59	7.3	5.0
62	8.0	5.6
63	6.9	5.0
64	7.7	8.6
67	7.8	5.8
70	8.4	6.5
71	7.9	7.6
73	7.9	6.4
74	7.4	7.6
74	7.4	9.4
74	7.4	6.8
89	7.4	5.1
90	6.9	7.3
91	7.1	9.5
94	7.4	7.6
97	6.4	6.8
99	5.9	8.6
101	5.7	5.1
102	6.8	5.8
102	6.8	4.4
109	7.0	2.2
1481	7.0	6.2
1599	7.2	8.1

$r = -0.118$

normal range of males as 40 to 54. There was no difference between the means of the White patients and the Negro patients. Urines for 478 patients were tested for albumin, reducing substances, specific gravity and a microscopic examination of the sediment of the centrifuged sample was done. No abnormal urines were found.

TABLE 6

MEAN TOTAL [illegible] PROTEIN FOR [illegible] CASES OF FROST-BITE [illegible] TO [illegible] OF INJURY

Degree of In[illegible]	[illegible] of [illegible]	Mean Total Serum Protein g[illegible]s/100 [illegible]	Standard Deviation
Fi[illegible]	[illegible]	[illegible].16	± 0.411
Se[illegible]	45	7.22	± 0.528
Third	77	7.39	± 0.49[illegible]
Fourth	2[illegible]	7.[illegible]	± 0.6[illegible]1

TABLE 7

MEAN SERUM ALBUMIN FOR 269 CASES OF FROSTBITE ACCORDING TO DEGREE OF INJURY

Degree of Injury	No. of Cases	Mean Serum Albumin gms/100 cc.	Standard Deviation
First	[illegible]	4.73	± 0.321
Second	14[illegible]	4.65	± 0.321
Third	72	4.63	± 0.431
Fourth	[illegible]	4.17	± 0.455

TABLE 8

MEAN ALPHA GLOBULIN FOR 268 CASES OF FROSTBITE ACCORDING TO DEGREE OF INJURY

Degree of Injury	No. of Cases	Mean Alpha Globulin % of Total Protein	Standard Deviation
First	30	8.8	± 3.56
Second	141	8.7	± 3.39
Third	72	9.4	± 3.48
Fourth	25	10.4	± 3.72

TABLE 9

MEAN BETA GLOBULIN FOR 272 CASES OF FROSTBITE ACCORDING TO DEGREE OF INJURY

Degree of Injury	No. of Cases	Mean Beta Globulin % of Total Protein	Standard Deviation
First	31	10.4	± 2.83
Second	143	10.8	± 3.63
Third	73	11.4	± 3.26
Fourth	25	12.2	± 3.76

TABLE 10

MEAN GAMMA GLOBULIN FOR 144 WHITE PATIENTS ACCORDING TO THEIR DEGREE OF INJURY BY FROSTBITE

Degree of Injury	No. of Cases	Mean Gamma Globulin % of Total Protein	Standard Deviation
First	23	13.9	± 2.27
Second	[illegible]7	14.7	± 2.91
Third	[illegible]	14.8	± 2.61
Fourth	[illegible]	18.8	± 2.62

TABLE 11

MEAN GAMMA GLOBULIN FOR 129 NEGRO PATIENTS ACCORDING TO THEIR DEGREE OF INJURY BY FROSTBITE

Degree of Injury	No. of Cases	Mean Gamma Globulin % of Total Protein	Standard Deviation
First	9	17.1	± 2.89
Second	67	18.2	± 2.90
Third	42	18.5	± 3.02
Fourth	11	21.0	± 2.80

TABLE 12

SIGNIFICANCE OF DIFFERENCE
OF MEANS FROM TABLES 6-11

Serum Protein Fraction	Fourth Degree vs. First Degree		Fourth Degree vs. Second Degree		Fourth Degree vs. Third Degree	
	t	P	t	P	t	P
Total Protein	0.751	>.40	0.409	>.60	0.786	>.40
Albumin	5.183	<.001	5.064	<.001	4.422	<.001
Alpha Globulin	1.624	>.10	2.136	<.05	1.166	>.20
Beta Globulin	1.981	>.05	1.737	>.05	0.955	>.20
Gamma Globulin White	15.625	<.001	4.409	<.001	4.107	<.001
Gamma Globulin Negro	3.058	<.01	3.061	<.01	2.601	<.02

IV. DISCUSSION

No statistically significant change in any of the protein fractions was noted during the 4 weeks of observation. This indicated that the protein requirements for these subjects had not only been adequately met just prior to reaching Osaka, but also during their hospitalization. It appears, therefore, that the protein content of the diets prescribed for army hospitals is adequate for convalescence from frostbite. No values were obtained from either healthy hospital personnel or other soldiers returned from Korea with which the frostbite data could be compared. A group of 300 soldiers on field maneuvers in Colorado had a range of 5.8 to 7.0 grams of serum protein per 100 cc. during the summer months and 6.2 to 6.5 grams during the winter. The racial differences found among the hospital patients were similar to those found in studies of normal healthy males in North Carolina (12) and in a rural population of Tennessee (3). Youmans (3) emphasized that, since the total protein is the sum of the albumin and globulin fractions,

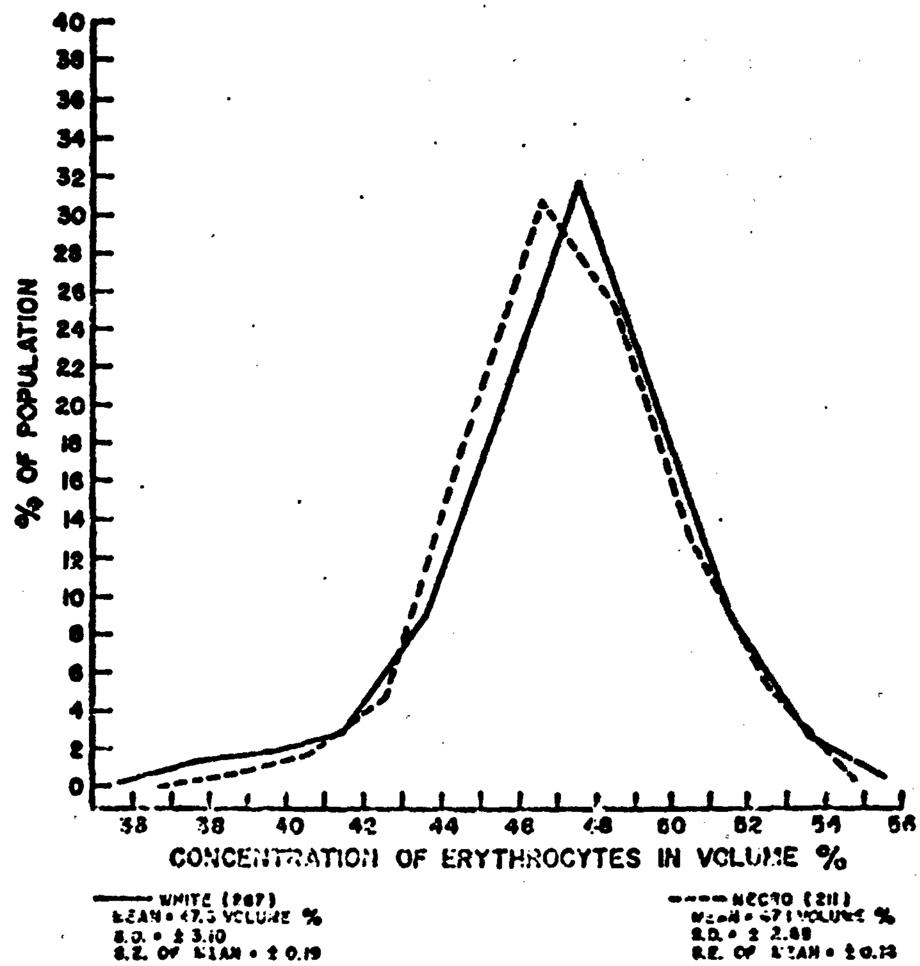


FIGURE 8. DISTRIBUTION OF HEMATOCRIT VALUES OF FROSTBITE PATIENTS UPON ADMISSION TO OSAKA ARMY HOSPITAL.

it is possible to have a low albumin and high normal globulin giving a normal total serum protein. He found that 9% of his subjects had hypoalbuminemia but that 89% of these had normal total serum proteins. Youmans found no correlation between the level of serum albumin and the intake of calories, total protein or animal protein in the civilian population he studied. However Kark et al (13), studying United States, Indian and Burmese troops in the tropics, found a "reasonable correlation" between the serum protein levels and the protein intake of these groups. Globulin is relatively much less affected by nutritional deficiencies than albumin but, on the other hand, is more affected by such factors as infections. Peters and Eiserman (9) found that during the winter months high globulin values seemed to be more common among Connecticut subjects. They postulated that the high values were probably due to mild respiratory infections prevalent in that climate and during that season. Since there were no appreciable secondary infections or complications other than frostbite among the subjects of this study, it was felt that this factor was negligible.

No satisfactory explanation could be found for the significantly lower albumin and higher globulin values present in the sera of fourth degree frostbite patients.

The protein levels of the vesicular fluids were slightly higher than those found by Orr and Fainer (14) in three frostbite patients during the winter of 1950-51. Similar values were found in human subjects by Cornblect (15), Lustig and Nassau (16) and by Harkins and Harmon (17) in blisters both naturally occuring in disease and induced by cantharidin plasters.

V. SUMMARY AND CONCLUSIONS

The levels of the serum protein fractions were determined for

frostbite casualties occurring in Korea during the winter of 1951-52. The serum protein fractions for all patients studied were within normal limits. However, a statistically significant difference was found between the serum protein levels of White and Negro subjects. The total protein, albumin, alpha globulin, beta globulin and gamma globulin were found to be essentially normal on the day of admission to the hospital and were unchanged when rechecked on the fourteenth and thirtieth day of hospitalization. The fact that these various protein fractions were maintained at essentially normal levels indicated that the protein content of the diet was adequate. Significant differences were found between the means of the albumin, alpha globulin and gamma globulin fractions when comparing fourth degree cases with less severely frostbitten patients.

The total protein of the blister fluids was compared with the protein levels of the corresponding sera. Although some very high values were obtained the protein content of the blister fluids was in most cases lower than that of the sera.

VI. BIBLIOGRAPHY

1. Pollack, H. and S. L. Halpern. Therapeutic nutrition with special reference to military situations, Washington, D. C., National Research Council, January 1951.

2. Sinclair, H. M. The assessment of human nutrition, New York, Academic Press Inc., 101, 1948.

3. Youmans, J. B., E. W. Patton, W. R. Sutton, R. Kern, and R. Steinkamp. Surveys of nutrition of populations; protein nutrition of a rural population in middle Tennessee. Am. J. Pub. Health 33: 955-964, 1943.

4. Wolfson, W. Q., C. Cohn, E. Calvary and F. Ichibar. Studies in serum proteins V.: A rapid procedure for the estimation of total protein, true albumin, total globulin, alpha globulin, beta globulin and gamma globulin in 1.0 ml of serum. Am. J. Clin. Path. 18: 723-730, 1948.

5. Consolazio, C. F., R. E. Johnson and E. Marek. Metabolic Methods, St. Louis, The C. V. Mosby Co., 1951.

6. Bean, W. B., J. B. Youmans, W. F. Ashe, N. Nelson, D. M. Bell, L. M. Richardson, C. E. French, C. R. Henderson and R. E. Johnson. Field test of acceptability and adequacy of U. S. Army C, K. 10-in-1 and Canadian Army mess tin rations. AMRL Project No. 30, November 1944.

7. Anderson, C. G. and A. Altman. Electrophoretic serum protein patterns in malignant malnutrition. Lancet 1: 203-204, 1951.

8. Lewis, L. A. Electrophoresis in physiology, Springfield, Chas. C. Thomas Co., 1950.

9. Peters, J. P. and A. J. Eiserman. Serum protein in diseases not primarily affecting the cardiovascular system or the kidneys. Am. J. M. Sc. 186: 808-833, 1933.

10. Luetscher, J. A. Jr. Electrophoretic analysis of the proteins of plasma and serous effusions. J. Clin. Investigation. 20: 99-106, 1941.

11. Sunderman, F. W. and F. Boerner. Normal values in clinical Medicine, Philadelphia, The W. B. Saunders Co., 1950.

12. Milam, D. F. Plasma protein levels in normal individuals. J. Lab. and Clin. Med. 31: 285-290, 1946.

13. Kark, R. M., H. F. Aiton, E. D. Pease, W. B. Bean, C. R. Henderson, R. E. Johnson and L. M. Richardson. Tropical deterioration and nutrition. Medicine 26: 1-40, 1947.

14. Orr, K. D. and D. C. Fainer. Cold injuries in Korea during winter of 1950-51. Medicine 31(2): 177-220, 1952.

15. Cornbleet, T. The Donnan Equilibrium and blister formation. J. Invest. Dermat. 4(6): 451-458, 1941.

16. Lustig, B. and E. Nassau. The carbohydrate content of the proteins in blood serum, cantharidin blisters and pleural effusions. Am. Rev. Tuberc. 43(6): 817-824, 19[illegible].

17. Harkins, H. N. and P. H. Harmon. Thermal injuries: the effects of freezing. J. Clin. Investigation 16:213-221, 1937.

U. S. GOVERNMENT PRINTING OFFICE: 1953 O - 257969